Supplement to *HortScience*

**Volume 53(9) September 2018**

This supplement contains the abstracts of presentations from the following National Conference and Regional Meetings of the American Society for Horticultural Science

**ASHS Annual Conference**
31 July–3 August 2018, Washington, D.C. .........................S1

**Southern Region ASHS Annual Meeting**
2–4 February 2018, Jacksonville, FL ............................S453

Please note that abstracts from the **2018 ASHS Northeast Region Annual Meeting**  
9–10 January, 2018, Philadelphia, PA  
were published as part of the Proceedings of the Northeastern Plant, Pest, and Soils Conference (2018) and can be accessed online at  

For best viewing, the supplement should be downloaded in its entirety to your computer.  
It is best viewed using Adobe Acrobat Reader.
Abstracts of Presentations
from the
Annual Conference
of the
American Society for Horticultural Science
31 July–3 August 2018, Washington, D.C.

Supplement to HortScience
Volume 53(9), September 2018

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For citation purposes, abstracts should be cited as shown in the following example:


American Society for Horticultural Science
1018 Duke Street, Alexandria, VA 22314
phone: 703.836.4606 • fax: 703.836.2024 • ashs.org • ashs@ashs.org
**Information Is Everywhere! How Do I Protect It and Use It Properly?**

*Objectives:* The objective of this workshop is to clarify the laws and guidelines for copyright and use of scholarly and creative works. Participants will gain practical knowledge for protecting their work and lawfully using the work of others.

*Description:* The impacts of information ownership, copyright, and use are woven throughout our professional lives. Do you know how to share your work while protecting your rights? On the flip side, are you sure you’re using the work of others lawfully? In this engaging workshop, you’ll be guided by legal and policy experts to solve the mysteries of copyright in research, publishing, and instruction. The bulk of the workshop will consist of a roundtable discussion session which will provide the opportunity to discuss several common copyright scenarios with panelists. Panelists will guide participant groups in discussions of each scenario, and these groups will work together to clarify legalities and come to a consensus on best practices. Case studies/scenarios to be addressed will include:

1. **My government funded research grant has a public access requirement.** Once public access has been granted, who owns the data? How does this affect subsequent publication? What if my publisher wants exclusive rights?

2. **I want to use someone else’s published research data for a follow-on study.** Can I do this? From whom do I get permission?

3. **I am writing an Extension fact sheet about organic fertilizers.** I found a table from another University that clearly lists nitrogen analysis of various organic fertilizers. Can I use this table as-is in my publication? Can I reformat it for my publication?

4. **I published an article in a journal.** What rights to I retain as the author? How can others use what I’ve published? Are rights and restrictions consistent across different journals?

5. **I want to use images I found online in my presentation.** Do I need to get permission? How do I credit images properly? Can I post this presentation on my website or on Slideshare?

6. **I am an Extension Educator and developed a powerpoint slideshow on growing tomatoes.** A Master Gardener wants to use it to give a presentation to a garden club. Do I own this presentation, or does my University? What are some things I should consider before sharing my powerpoint with others?

**1:00 PM – 1:20 PM**

**Horticultural Copyright 101**

Hope O’Keefe*
Library of Congress, Washington, D.C., USA

Hope O’Keefe, Senior Associate General Counsel for the Library of Congress, supervises all collections matters including acquisitions, copyright, intellectual property, social media, web archiving, and increasing digital access to Library collections. As we delve into various case studies, Hope will offer broad insight to answer the fundamental copyright questions that arise in our work every day, ranging from publications to open science to big data.

**1:20 PM – 1:40 PM**

**Publishing in the Electronic Age: Rights and Restrictions**

Vicky Crone*
National Agricultural Library, Beltsville, MD, USA

Vicky Crone, Licensing and Procurement Librarian at the National Agricultural Library, will offer insight on licensing and paid access terms, rights, and restrictions in publishing, considerations for electronic and international publishing, and communication and collaboration between copyright holders and publishers. Vicky will help us explore and discuss case studies that illustrate these topics to foster a clearer understanding of licensing issues.

**1:40 PM – 2:00 PM**

**Fair Use: What Is It and How Do I Apply It?**

Krista Cox*
Association of Research Libraries, Washington, D.C., USA

Krista Cox, Director of Public Policy Initiatives for the Association of Research Libraries, will guide participants through fair use, which is an essential right that allows the use of copyrighted material without permission from the rightsholder under certain circumstances. The law encourages authors by giving them limited control over certain uses of their works, and it encourages everyone (including authors) to use existing cultural and scientific material without permission, under certain circumstances.
circumstances, to engage in a wide variety of vital activities. Krista will help us determine how fair use applies to different areas of research, instruction, and publishing through discussion of various practical case studies.

2:00 PM – 2:30 PM

**Question and Answer Period**

Emily Tepe*

University of Minnesota, St Paul, MN, USA

The workshop will conclude with a Q and A session in which the floor will be opened to specific participant questions. Speakers will provide insight and answers to these questions, and promote discussion to clarify the application of copyright and use laws, principles, and best practices to a broad range of situations. Participants will come away from the workshop with practical tools and resources for protecting their own work and properly using the work of others.

*CEU Approved*

**Systems Approach to Ecophysiology and Instrumentation: Technology and Instrument Demonstration**

*Coordinators:* Yan Chen

Louisiana State University Agriculture Center & Research Station, Hammond, LA, USA

Catherine Simpson

Texas A&M University, Kingsville Citrus Center, Weslaco, TX, USA

*Moderator:* Yan Chen

Louisiana State University Agriculture Center & Research Station, Hammond, LA, USA

**Objectives:** The objective of this workshop is to showcase innovative and exciting technologies and products recently developed for measuring plant water and nutrient status and related stresses. Workshop format includes presentations, videos, hands-on demonstrations, and a panel discussion. Through these activities, we expect to facilitate the learning of new technologies and the future application of featured devices in the research fields of workshop attendees.

**Description:** New development of innovative technologies and products have opened up exciting opportunities for more directly and precisely quantifying plant water and nutrient status and the responses of plants to related stresses. New technologies showcased in this workshop include (by the order of presentation): 1) overview of instruments developed to measure plant water status, such as tree hydration; 2) microtensiometer for measuring stem water potential; 3) thermal imaging devices for quantifying plant water stress; 4) sensing technology for analyzing nutrient status in fruit trees; and 5) laser mediated nucleic acid delivery system that can enhance the uptake of foliar applied chemicals by fruit trees. Renowned experts from both industry and academia will introduce the design theories, review the scientific promises of the featured products, and demonstrate the applications either by videos (nutrient sensors, TDR system, and laser mediated nucleic acid delivery system) or on-site installation and remote data collection (i.e., microtensiometer, infrared radiometers, sap flow velocity and nutrient sensors). There are, however, limitations to have some of the instruments available at the workshop. For example, operating an X-ray instrument requires different levels of certification in different states.

1:00 PM – 1:15 PM

**Instruments and Approaches to Measure Tree Water Status**

Bruce Bugbee*

Utah State University, Logan, UT, USA

1:15 PM – 1:30 PM

**Continuous In Situ Monitoring of Plant Stem Potential with an Embedded Microtensiometer**

Alan Lakso*

Cornell University, Geneva, NY, United States

Plant water potential is increasingly recognized as key for regulating both growth but also product quality. Directly measuring plant water potentials (preferably stem potential and continuously) is a key goal to replace the pressure chamber. To do this we have developed, using nanofabrication, a small size (in a probe about 6 mm diameter and 1 cm length), inexpensive, electronic, large-range, continuous-reading water potential sensor for monitoring soil water potential and embedding directly in the stems to monitor stem potentials, especially in woody plants. The sensor is a microfluidic device with the same principle as the common soil tensiometer, but with a much smaller volume and about 100X greater range. The microtensiometer has been successfully tested embedded in the stems of field apples, grapes and almonds over months. The high spatial and temporal resolution of plant and soil $Y_w$ provided by the microtensiometer should be a valuable tool for precision irrigation programs, research, and modeling.

1:30 PM – 1:45 PM

**Thermal Imaging of Plant Canopies for Quantifying Water Stress**

Bruce Bugbee*

Utah State University, Logan, UT, USA

1:45 PM – 2:00 PM

**Using Stable Isotope Tracers and X-Ray Fluorescence to Track Nutrient Movement and Distribution in Plants**

Lee Kalcsits*

Washington State University, Wenatchee, WA, USA

An asterisk (*) in front of a name indicates the presenting author.
Laser Mediated Nucleic Acid Delivery System
Ed Etxeberria*
University of Florida, Lake Alfred, FL, USA

Application of nucleic acid phytoremediation technology in agriculture has been stifled by the inability to target the nucleic acid components to the desired tissues. Under laboratory conditions using young seedlings, nucleic acid absorption through roots has been partially successful in treating a variety of biotic stresses. However, such techniques are not applicable to larger plants whether in pots or in the field. Laser technology has been shown effective in amplifying the uptake of applied substances, nano-particles and RNAi when applied to leaves. The technique consists of using laser energy to create perforations on the plant surface to allow the movement of nucleic acids (or other substances) into the plant and their eventual distribution by the vascular tissue. Trial experiments using RNAi against chlorophyll formation and targeted experiments against disease-carrying feeding insects have demonstrated the usefulness of this technology.

*CEU Approved*

How to Build a Blockbuster Funding Program for Horticulture through Politics, Partnerships and Perseverance

Coordinator: Thomas Björkman
Cornell University, Geneva, NY, USA

Objectives: The Specialty Crop Research Initiative (SCRI) was the result of a stakeholder-driven initiative in partnership with USDA. In response, Congress created a competitive grant program to allow a scale of horticultural research not seen before in the United States. Much of its impact has been achieved because of its systems approach with trans-disciplinary expectations and genuine stakeholder engagement. The SCRI has never received full funding, but project outcomes are helping protect and transform diverse specialty crop industries throughout the country. This session will describe how the initiative began and how continuing alliances keep this influential program growing and effective.

Description: People deeply involved with the creation of SCRI will describe how this novel initiative came to be, and how we can build on it. The session will open with a description of how specialty crop research was funded before SCRI, and the needs that were going unmet. Pairs of researchers and industry stakeholders will describe how their alliances began and have prospered. ASHS leaders will describe their organizing and advocacy role. ARS and NIFA leaders played essential communication roles. Finally, members of Congress and their agricultural staffers wrote excellent legislation that was adopted.
Cheap Sensors for Good Data: Economical Approaches for Research

Coordinator: Christopher J. Currey
Iowa State University, Ames, IA, USA

Objectives: The objective of this interactive workshop is to demonstrate equipment that can be used to quantify the growing environment and plant growth and stress that is not only accurate and informative, but economical to build and/or purchase.

Description: Quantifying the growing environment, substrate moisture and irrigation, and plant growth, development and stress are essential for horticultural science. However, the instrumentation to collect these data can be cost-prohibitive for researchers. Fortunately, there are economical alternatives. This workshop is designed to provide cost-effective, economical sensor and instrument solutions. In this workshop, attendees will be placed into groups and participants will rotate among five different interactive stations, each with demonstrations of different economical sensors and instruments that are broadly applicable across horticultural research.

3:15 PM – 3:30 PM
Welcome and Workshop Orientation
Christopher J. Currey*
Iowa State University, Ames, IA, USA

3:30 PM – 3:45 PM
Low-cost Sensors for Logging Light, Temperature, Humidity, and Crop Height (Station 1)
Marc van Iersel*
University of Georgia, Athens, GA, USA

3:45 PM – 4:00 PM
Quick, Easy and Cheap Measurements of Leaf Area and Canopy Coverage (Station 2)
Jun Liu*
University of Georgia, Athens, GA, USA
Theekshana C. Jayalath*
University of Georgia, Athens, GA, USA

4:00 PM – 4:15 PM
Plant Robotics: Precision Labor with Arduino and Raspberry Pi (Station 3)
Alexander G. Litvin*
Iowa State University, Ames, IA, USA

3:15 PM – 3:30 PM
Smartphone Accessories for Measuring Plant Input Needs (Station 4)
Krishna Nemali*
Purdue University, West Lafayette, IN, USA

4:30 PM – 4:45 PM
Monitoring and Controlling Irrigation Using Soil Moisture Sensors (Station 5)
Rhuanito S. Ferrarezi*
University of the Virgin Islands, Kingshill, USA

Strategies for Recruiting Students into Horticulture Programs

Coordinators/Moderators: Mary Meyer
University of Minnesota, Chaska, MN, USA
John Dole
North Carolina State University, Raleigh, NC, USA
Susan Yoder
Seed Your Future, Kennet Square, USA

Objectives: 1) Present Seed Your Future’s BLOOM! campaign and show how it is increasing interest in horticulture and horticultural programs. 2) Learn from universities and industry organizations about their effective recruiting strategies and programs.

Description: All across the United States, universities and organizations are working to recruit young people into horticultural programs to help them find their passions and fill the need for well-trained employees. Leading the charge is Seed Your Future, which is comprised of a broad range of horticultural industry, universities and organizations. Seed Your Future’s National Leadership Cabinet and Advisory Council continue to lead the national movement to promote horticulture in collaboration with FleishmanHillard, the Washington, D.C.-based marketing and communications firm. Progress in the past year included finalizing the BLOOM! campaign: BLOOM! is the movement to improve the world through the power of plants through a comprehensive multi-year plan to create and curate content (both in and outside of the classroom) and deploy a social media strategy. In March 2018 the Scholastic site for BLOOM! was launched, where all the materials developed through Scholastic for teachers and youth program leaders are accessible. This great start is providing resources to those who work with middle schoolers <www.Scholastic.com/BLOOM>. Additionally, the youth-focused WeAreBLOOM.org microsite went live on 7 Mar. 2018, when teachers began to distribute the student magazines and held the first student contest, entitled plant mash-up, encouraging students to create their own new plants. BLOOM! has exciting attractive images, words and information that are designed to connect with young people. Elements of the movement include promoting #GreenCollar careers,
ground-breaking interviews with horticulturists, identifying horticulture heroes, and creating videos made specially to attract and inform middle and high school students about careers in horticulture. BLOOM educational materials include websites, interactive quizzes, plant powers, horticulture vignettes, social first videos, social media campaigns, education multi-media with Scholastic, student magazines, online learning modules, and life lessons. The campaign will run from Apr.–Oct. 2018, which will be followed by assessment and year two planning. Seed Your Future is not working in a vacuum. Universities and industry organizations are successfully implementing their own programs to increase the number of horticulture students. In this workshop we will learn from universities and industry organizations about their effective recruiting strategies and programs.

3:15 PM – 4:00 PM
**Seed Your Future—The Education and Marketing Campaign Has Been Launched!**

Susan Yoder*
Seed Your Future, Kennett Square, USA

4:00 PM – 4:15 PM
**Undergraduate Recruitment of Horticulture Students: A West Texas Perspective**

David Montague*
Texas Tech University, Lubbock, TX, United States

4:15 PM – 4:30 PM
**ISU Horticulture: Branding Our Identity**

Cynthia Haynes*
Iowa State University, Ames, IA, United States

4:30 PM – 4:45 PM
**Center for Growing Talent—Bringing New Talent to the Fresh Produce and Floral Industry**

Alicia Calhoun*
Center for Growing Talent, USA

Margi Prueitt
Center for Growing Talent, USA

4:45 PM – 5:15 PM
**Discussion**

Wednesday, August 1, 2018

*CEU Approved*

**Teachers Ignite!**

*Coordinator/Moderator:* Andrew R. King
Texas A&M University, College Station, TX, USA

**Objectives:** A fast-paced introduction by eight presenters into pedagogical techniques utilized. Attendees will be able to take topics discussed during the workshop and incorporate them into their teaching efforts. They will also have opportunity to ask questions and take part in group discussions about how to most effectively integrate the topics discussed.

**Description:** A fast-paced format in which presenters have three minutes and one PowerPoint slide to introduce and describe novel pedagogy techniques (teaching techniques, methods and/or activities) that they have found to be successful in the classroom or in extension teaching efforts. Various interests and focus areas will be discussed in the workshop. Attendees will be encouraged to take part in group discussion about effective methods for incorporation of these ideas or methods that they find helpful.

8:00 AM – 8:05 AM
**Developing Pedagogical Strategies for Incorporating Plant Trials into the Classroom**

Andrew R. King*
Texas A&M University, College Station, TX, USA

8:05 AM – 8:10 AM
**Creating an Interactive Syllabus**

Kimberly Moore*
University of Florida/IFAS, Fort Lauderdale, FL, USA

8:10 AM – 8:15 AM
**Utilization of a Service Learning Project to Engage Classrooms of 300+ Students**

Charles R. Hall*
Texas A&M University, College Station, TX, USA

8:15 AM – 8:30 AM
**Question and Answer Break**

8:30 AM – 8:35 AM
**Horticulture Is Awesome: Assessing Student Learning and Interest via Blog Posts**

Jared Barnes*
Stephen F. Austin State University, Nacogdoches, TX, USA

In Spring 2017, we created a portfolio website for the horticulture program at Stephen F. Austin State University to promote student work to help engage potential students. Learning opportunities with this platform and blog will be discussed.

8:35 AM – 8:40 AM
**Virtual Field Trip—Fantastic Voyage!**

Kent Kobayashi*
University of Hawaii at Manoa, Honolulu, HI, USA

Classes go on actual field trips to supplement in-class learning and activities, visiting places such as farms and nurseries. The instructor contacts the farm or nursery owner, explaining the
purpose of the visit and what the class would like to see. A date and time is finalized, and transportation is arranged. However, field trips have some shortcomings. They are limited to visiting places on the island of Oahu and close to the University of Hawaii because of the transportation costs and time. Once at the farm or nursery, it is sometimes difficult for everyone in the group to see or hear the speaker. Some students wander off from the group or are inattentive. Transportation can be costly. To complement field trips, I created the virtual field trip assignment. Each student contacts the owner of a farm or nursery, explains the assignment, and gets permission to visit for a personal tour. The student interviews the owner about the operation and takes pictures. Later, each student gives a PowerPoint talk in class about the farm and writes a report about the visit. The advantages of a virtual field trip include students are free to choose the farm or nursery that they want to visit. This could be a farm on another island in Hawaii, the U.S. mainland, or in a foreign country. The student may be able to see and hear about things that the owner would not show or tell to a large group of students. The class gains experience in oral and written communication. This networking opportunity could possibly lead to an internship or a job. One of the things that did not work was when students were given the option of working in pairs, the work was sometimes not equally divided. Only one student in a group visited the farm or nursery. In conclusion, virtual field trips can complement actual field trips. The class learns firsthand about a diverse range of farms and nurseries. Students have the opportunity to improve oral and written communication. Virtual field trip visits have led to students getting future internships or jobs.

8:40 AM – 8:45 AM
The Use of Student Preceptors to Make a Large Class Smaller
Dennis Ray*
University of Arizona, Tucson, AZ, USA

8:45 AM – 9:00 AM
Question and Answer Break

9:00 AM – 9:05 AM
An Interdisciplinary Project: Creating the Marketing Tools for Horticultural Business
Jacqueline Ricotta*
Delaware Valley University, Doylestown, PA, USA

9:05 AM – 9:10 AM
The Good, the Bad, and the Ugly: Critique As a Teaching Tool in a Landscape Design Course
Whitney N. Griffin*
Texas A&M University, College Station, TX, USA

9:10 AM – 9:30 AM
Group Discussion

An asterisk (*) in front of a name indicates the presenting author.

*CEU Approved*

**Early Plant Collectors: Contributions and Tribulations**

*Coordinator/Moderator: Nahla V. Bassil*
USDA-ARS Corvallis, Corvallis, OR, USA

**Objectives:** Give an overview of early U.S. plant explorers who were responsible for introducing the variety of fruits we enjoy now: Their adventures, contributions and challenges

**Description:** The United States has a rich history of plant collection. As emigrants came to this country, they transported familiar plants with them. During the 1700s, merchants, naval officers, and government officials imported plant material. Wealthy collectors also sponsored expeditions for exotic plant species. In 1728, John Bartram purchased land in Pennsylvania and began collecting North American plants for his private garden and nursery business. It was not until 1858 that federal funds provided by the U.S. Commissioner of Patents were used for the collection of tea by Robert Fortune in China. With the creation of the Office of Foreign Seed and Plant Introduction in 1898, plant explorers were sent to remote areas of the world to search for useful germplasm that would survive harsh climatic and edaphic conditions in the United States. In spite of life-threatening hardships endured during these expeditions, David Fairchild, Niles Hansen, Walter Swingle, and Frank Meyer collected many progenitors of the commercial fruit and nut cultivars grown today in North America.

8:00 AM – 8:10 AM
Introduction to the Workshop
Michele Warmund*
University of Missouri, Columbia, MO, United States

8:10 AM – 8:25 AM
John Bartram: America’s First Botanist
Richard Marini*
Pennsylvania State University, University Park, PA, USA

John Bartram (1699–1777) was born in Marple, PA. He was a Quaker farmer turned botanist and journeyed throughout eastern North America, from Canada to Florida, and described the plant and animal life he encountered. He corresponded with and sent seeds of native plants to European scientists and gardeners. He was appointed the “Royal Botanist” by King George III, and along with Benjamin Franklin he was a founding member of the American Philosophical Society. Carl Linnaeus said he was the “greatest natural botanist in the world”. Bartram purchased a farm in Philadelphia and started the first botanical garden in America, where he planted many of the specimens he collected on his trips. He collected apple cultivars and had a cider press. Part of the farm (Bartram’s Garden) is currently preserved by the city of Philadelphia. His son, William Bartram, continued to explore the southeastern North America and described the Native Americans and the native plants he encountered.
An asterisk (*) in front of a name indicates the presenting author.

8:25 AM – 8:40 AM

**Neils Ebbesen Hansen: A Man with a Vision for the Unfathomable**

Marvin Pritts*
Cornell University, Ithaca, NY, USA

Neils Hansen was a man of the north. While other plant explorers ventured to tropical islands and rainforests in search of potentially economical plants, Hansen ventured to the high latitudes of Europe and Asia to find hardy species that would perform well in the cold, dry, windy northern tier of states. Hansen was born in Denmark in 1866 and immigrated to New York at the age of seven. In 1883 he enrolled in Iowa Agriculture College in Ames. After graduation he worked at a grape nursery where his interest in fruit took hold. He later returned to Iowa for his MS degree where he worked for J.L. Budd, an expert on Russian plants and fruit crops. In 1890 he and Budd wrote and published a “Handbook of Fruit Culture and Tree Planting for the Northwestern States.” Upon graduation in 1895, Hansen was appointed chair of the new horticulture department at South Dakota State University and, later, appointed head of the experiment station. This position afforded him the opportunity to travel eight times to northern Europe and Asia in search of hardy plants. James Wilson, U.S. Secretary of Agriculture, asked Hansen if he would accept an offer to go on a federally-funded 10-month plant collection expedition to northern Asia during the winter of 1895. He accepted and, “outfitted with a dagger on his right side, a revolver in his belt, field glasses, and magnifying lenses,” collected five car loads of seeds and buds. Wilson said, “I have 12,000 men under me, but none who knows how to work like Hansen.” He was the originator of many new fruit cultivars, among them hybrid plums, apricots, and red-fleshed apples, and also alfalfa and grasses. At one point his collection of fruit seedlings (250,000) was among the largest in the world, second only to the collection of Luther Burbank. He released 113 varieties of apples and crabapples; 72 varieties of plums, cherries and sand cherries; and 35 varieties of grapes. Few have ever heard of Professor Hansen, but he did more than perhaps any other man to transform the Great Plains from a desert to the bread basket of America.

8:40 AM – 9:00 AM

**Walter Tennyson Swingle: A Relentless Intellect That Transformed American Pomology**

Ed Stover*
USDA-ARS, Ft Pierce, FL, USA

Walter Tennyson Swingle grew up outside of Manhattan, Kansas, and was notorious in his passion for botany. Based on observations, he made up his own names for plants that were demonstrably different. His formal engagement with science was ignited when he discovered that plant names and taxonomic distinctions could be found in books! He attended classes at Kansas Agricultural College at 15, and when he graduated at 20 he had already published 27 scientific papers in plant pathology, plant breeding and genetics. Swingle joined the USDA in 1891, and in July was sent to Florida to investigate diseases in orange trees. He established a USDA laboratory and began a comprehensive program to breed disease- and frost-resistant citrus. He recognized the need for genetic diversity in crops and the risks of growing them in monocultures. He discovered some new species and several new genera: the genus *Swinglea* and several cultivars were named in his honor. In the citrus crosses he made or directed, he originated several new categories of citrus: the tangarol, citranges and citrulmelo (now critical as rootstocks), and several other intergeneric hybrids. He conducted plant exploration, mainly in countries surrounding the Mediterranean, and introduced date palms, figs, table grapes, and ‘Clementine’ mandarins. He also brought in the *Blastophaga* wasp to pollinate Smyrna-type figs. In his duties in the USDA section of Seed and Plant Introduction, he received over 2000 plant introductions, but hundreds of accessions in GRIN list Swingle as the collector. After his retirement from the USDA, Swingle moved to Miami in 1943. It was here he completed his treatise on the taxonomy of the citrus subfamily. “Even in his retirement, Swingle inspired a generation of students with his knowledge, curiosity of nature, and insights into plants. His simple advice to students was “Look and look, again and again,” words still relevant today”.

9:00 AM – 9:15 AM

**David Grandison Fairchild: Plant Hunter Extraordinaire and Father of Foreign Seed and Plant Introduction**

Nahla V. Bassil*
USDA-ARS Corvallis, Corvallis, OR, USA

David Fairchild was born in 1969 in East Lansing, MI. He became a plant pathologist, geneticist and world renowned plant explorer. At 20 years of age, he joined the United States Department of Agriculture as a pathologist. In 1897, Fairchild and his friend Walter Swingle convinced Secretary James Wilson to start a new program he named “The Section of Foreign Seed and Plant Introduction.” Fairchild was immediately hired to run it. He traveled the world with wealthy sponsors Lathrop Barbour and later on with Alison Armour who funded some of his plant explorations. He was passionate about introducing Americans to the foods of the world he visited through introductions and subsequent selection. By the time he retired from the USDA, 111,857 varieties of plants and seeds were introduced into the United States by Fairchild and his plant hunters. Among them were apricots, apples, muskelmons from Chinese Turkestan; citron from Corsica; nectarines from Pakistan; cherries from Siberia; dates from Egypt and Algeria; pear cultivars from Germany; and many clones of mango and avocado now important to Florida’s industry. In 1912, he also helped coordinate the arrival of the Japanese flowering cherry trees that blossom each spring around Washington’s Tidal Basin. He published over 400 articles and four books. The Fairchild Tropical Botanic Garden was established with his help on an 83-acre site south...
works on the development of commercial fruit and nut cultivars. He collected more than 2500 plant introductions, but only content when collecting economically useful plants. While collecting more than 2500 plant introductions, he drowned under mysterious circumstances on the Yangtze River. Many of the genetically-useful traits in commercial fruit nut cultivars today originated from germplasm introduced to the United States by this dauntless plant collector.

*CEU Approved*

How Agricultural Research Gets Done in the US Federal Government: From Congress and Budgets to University and Industry Partnerships

Coordinator/Moderator: John Beaulieu
USDA ARS, New Orleans, LA, USA

Objectives: The Federal Partners Professional Interest Group presents a significant speaker session and panel of USDA Under Secretary, Administrators and National Program coordinators. They will deliver information regarding the major agricultural research agencies, the National Agricultural Statistics Service (NASS) conducts the Census of Agriculture and provides the official, current statistics on agricultural production and indicators for the economic and environmental welfare of the farm sector. REE programs work to solve some of the most challenging problems in food and agriculture. Our scientists are researching ways to enhance crop production, including breeding new varieties, creating cost-saving technologies such as precision agriculture, and developing methods to adapt agriculture to changing climate conditions. Our research also provides scientific approaches for protecting agriculture while producing a food supply that is abundant and safe.

Description: The four invited speakers will deliver roughly 15–20 minute talks followed by a panel session, round-table format Q&A. Chavonda Jacobs-Young will give a USDA overview in her role as the Acting Undersecretary for REE and Chief Scientist. Simon Liu, Associate Administrator, will give an overview from ARS’ perspective: regarding how five year research projects operate. In the USDA ARS, the National Program Staff (NPS) directs research, and the Office of Scientific Quality Review (OSQR) program functions whereby review teams are our university and industry colleagues. Gene Lester will discuss several horticultural issues and how research and development in some national programs address societal and horticultural needs. Finally, Mojdeh Bahar, JD, will wrap everything together as she discusses how partnerships, patents and technology transfer paradigms and horticultural crops research and innovative are intertwined.

10:15 AM – 10:35 AM

Advancing Agricultural Research
Chavonda Jacobs-Young*
United States Department of Agriculture, Washington, USA

At the United States Department of Agriculture (USDA), much of our work is focused on finding solutions to the unprecedented challenges facing the world’s food and agricultural system. The global population is expected to reach over 9 billion people by 2050 and farming alone will not produce the food and fiber we will need. With diminishing land and water resources, we must use science and creativity to develop new technologies to help sustain our food production. USDA recognizes the role scientific research plays in spawning innovation and supports maintaining a vigorous research infrastructure. The Research, Education, and Economics (REE) mission area responsibilities are carried out by four agencies: 1) the Agricultural Research Service (ARS) conducts intramural research in natural and biological sciences; 2) the National Institute of Food and Agriculture (NIFA) provides research grant funding to scientists who work at U.S. land-grant universities and other public organizations, including Federal agencies; 3) the Economic Research Service (ERS) performs intramural economic and social science research; and 4) the National Agricultural Statistics Service (NASS) conducts the Census of Agriculture and provides the official, current statistics on agricultural production and indicators for the economic and environmental welfare of the farm sector. REE programs work to solve some of the most challenging problems in food and agriculture. Our scientists are researching ways to enhance crop production, including breeding new varieties, creating cost-saving technologies such as precision agriculture, and developing methods to adapt agriculture to changing climate conditions. Our research also provides scientific approaches for protecting agriculture while producing a food supply that is abundant and safe.

10:35 AM – 10:50 AM

The Five-year ARS Project Cycle: Research, Review, Revise
Simon Liu*
United States Department of Agriculture, Washington, USA
At the Agricultural Research Service (ARS), the chief in-house scientific research agency of the U.S. Department of Agriculture (USDA), our job is finding solutions to agricultural problems that affect Americans every day from field to table. To meet this mission, we have 2000 scientists and post docs and 6000 other employees who support 690 ARS research projects at more than 90 research locations across the United States and overseas. This work is funded by an annual appropriated budget of around $1 billion. Research by ARS scientists ensures the production of high-quality, nutritious, and safe food, as well as other agricultural products and co-products. Their work helps to protect and enhance our natural resources and the environment. Just as important, their findings help support a competitive agricultural economy, and create economic opportunities in rural communities and other markets. The 1998 Farm Bill called for USDA to establish procedures to perform scientific peer reviews of all ARS research projects to verify that its investigations have scientific merit and programmatic relevance. This review process is required at least once every 5 years, and uses a panel of external reviewers to assess the projects prior to implementation. To meet this mandate, ARS created the Office of Scientific Quality Review (OSQR) to manage and facilitate the ARS peer review process. This presentation will discuss how the OSQR process works, and how the peer-review process fits into the five-year cycle of an ARS research project.

10:50 AM – 11:05 AM

**Horticultural Research: A USDA Perspective**
Gene Lester*

USDA ARS/Quality and Utilization of Agricultural Products, Beltsville, MD, USA

Climate, water, food waste and quality are the interrelated areas of research. Food—in order to feed an estimated nine billion people by 2050 food supplies will need to double from current levels. The United States food system will have to increase the accessibility of safe and nutritious food, mostly from novel uses of plant products, as well as prevention of postharvest losses. It is one thing to produce more food, and it is another to insure that the food produced is consumed. Researchable, interrelated postharvest factors which impact food involve: Climate change—do changes in CO₂, drought and temperature affect food quality and shelf-life? Water—concerns for drought mitigation, which impacts production and environmental sustainability, must include ‘non-traditional’ waters involved in fruit and vegetable processing, grading, and storage. Food waste and quality—new approaches to prevent, reduce or recover food waste by reducing food perishability, improving storage atmosphere/temperature/humidity/lighting conditions, and food packaging systems which employ nanotechnologies with anti-microbial, antifungal and antioxidant properties. Consumer sensory (tastes, color and aroma), preferences and food habits will need to be exploited to enhance or develop new foods or food uses which aids food security.

11:05 AM – 11:20 AM

**Partnerships, Patents, Publications, and Products: An Overview of Tech Transfer**

Mojdeh Bahar*
USDA ARS, Beltsville, MD, USA

This session covers an overview of technology transfer paradigm, policies and innovative partnerships. The examples will be drawn from horticultural crops.

**CEU Approved**

**National Programs and Resources in Pest Management for Horticulture Researchers and Professionals**

Coordinator/Moderator: Mary Rogers
University of Minnesota, St. Paul, MN, USA

**Objectives:**
1) Provide an overview of current national programs and resources available to horticultural professionals that aid in pest management, including weeds, diseases, and insects. 2) Discuss ways horticulturists can use these resources to improve their work in research, Extension, and teaching. 3) Allow time to discuss new and emerging pest (insects, weeds, diseases) threats to horticultural industries.

**Description:** Management of weeds, diseases and insect pests in horticultural crops remains considerably challenging for producers. Stakeholders and land owners depend on knowledge and recommendations from professional horticulturists, including Extension educators, crop consultants, and researchers in order to manage endemic and invasive species. These challenges are increasing in complexity as we are faced to address risks posed by new invasive species, chemical resistance, labor shortages, new regulations on pest protectants, and climate change. In the horticultural crops sector, there is increasing demand from stakeholders for environmentally sustainable management practices that protect beneficial species such as pollinators and monarch butterflies, for example. Increasingly, management practices need to be effective but at the same time selective to limit negative effects on beneficial organisms. There are a number of national programs that can help horticulturists address these management challenges and develop robust research projects and outreach programs. The ASHS conference is the ideal venue for knowledge sharing and provides an opportunity for continued education, dialogue and discussion around dynamic national priority issues. In this workshop, we will highlight resources that horticulturists can connect with to improve research and outreach programs devoted to sustainable practices for weed, disease and pest management in fruit and vegetable production systems. Speakers will provide an overview of their programs and initiatives and describe how horticulturists may connect with or benefit from their programs. Participants will discuss the utility of current resources, identify any gaps in resources, and generate ideas for future endeavors. The last 30 minutes of the workshop will feature an interactive panel discussion with the...
three speakers to allow for general discussion. The moderator will be prepared with questions to stimulate discussion between the speakers and the audience members on the utility of the resources identified as well as highlighting other resources not covered here. We will also spend time discussing needs and priorities for managing newly emerging pests, diseases, and weeds significant to various horticultural industries.

10:15 AM – 10:35 AM

**USDA–NIFA’s Programs in Crop Protection**
Herbert Bolton*
USDA NIFA, N/A, USA

10:35 AM – 10:55 AM

**How the Regional IPM Centers Can Support Horticultural Science**
Joseph LaForest*
University of Georgia, Tifton, GA, USA

10:55 AM – 11:15 AM

**The First Detector Program: Training and Tools to Promote Early Detection**
Rachel McCarthy*
Northeast Regional Center for the National Plant Diagnostic Network, Ithaca, NY, USA

*CEU Approved*

**International Horticulture and Foreign Assistance: How Some Aid Agencies and Not-for-profit Organizations Use Horticulture (and how you can become involved)**

Coordinator/Moderator: John Griffis
Florida Gulf Coast University, Ft. Myers, FL, USA

Objectives: 1) To provide audience members with information about how horticulture plays an integral part of many Foreign Aid Programs. 2) To provide audience members with information about numerous projects and programs of Aid Agencies and NGO’s involved in U.S. foreign aid programs and how they use horticulture and horticulturists. 3) To provide audience members with specific information about how they can become involved in international horticulture programs and projects with these various Aid Agencies and NGOs. Audience members are encouraged to discuss their own experiences with these projects and programs. 4) To allow audience members to ask questions, make comments and discuss topics with regard to the importance of horticulture in various foreign assistance programs.

Description: The program will have two speakers from International Development Agencies—NGOs that subcontract with USAID. The speakers will explain how their programs use horticulture as an important part of their various projects (such as, but not limited to, projects associated with USAID and Feed the Future, Farmer-to-Farmer and some other USAID-funded program) and how our ASHS members can become involved with these programs, whether it be career track, consultant, coopera-
tor, intern or volunteer. Our panel of expert presenters will join together in a round-table question and answer panel discussion session after the two oral presentations. After brief comments/questions to initiate the panel discussion by the moderator, the audience will be invited 1) to ask questions of the panelists, including questions related to working for or with an agency that sub-contracts with USAID, 2) to discuss with the panelists topical international issues of concern or 3) to make comments concerning topics relevant to the general subject matter of international issues & networking that concerns the professional interest group. The moderator and the panelist from CNFA will ask audience members to discuss any previous volunteer horticultural experiences in Southern Africa and how they perceived those experiences. The moderator and the panelist from Winrock International will ask audience members to discuss or explain any experiences they have had in integrating youth into international horticulture projects of the various types presented by the panelist in his presentation. Audience members are also encouraged to offer responses to questions or comments posed by other members of the audience.

2:30 PM – 3:00 PM

**Horticulture in Southern African Economies – Why It Matters?**
Steven Jacobson*
Cultivating New Frontiers in Agriculture, Washington, D.C., USA

The presentation will focus on the importance of horticulture particularly in Southern Africa and discuss the role that the (USAID) Farmer-to-Farmer (F2F) program plays in generating rapid, sustained economic growth in the agricultural sec-
tor through short-term technical assistance provided by U.S. volunteers. Presentation will include a brief overview of F2F including examples of F2F volunteers and their work as well as short-term opportunities available at CNFA for horticulturalists.

3:00 PM – 3:30 PM

**Using Innovation to Engage Youth in Horticulture**
Peter Saling*
Winrock International, Arlington, VA, USA

Using technology and services as an entry point for engaging young people (aged 18–35), Winrock International is designing innovative programs to draw the next generation of horticultur-
als. While global trends suggest youth interest in agriculture is waning, by expanding what’s possible in agriculture we can attract men and women while improving productivity, efficiency, and employment opportunities in agriculture. You can help us do this.
**Workshops**

*CEU Approved*


*Coordinators:* Sheri Dorn  
University of Georgia, Griffin, GA, USA  
Natalie Bumgarner  
University of Tennessee, Knoxville, TN, USA

*Moderators:* Sheri Dorn  
University of Georgia, Griffin, GA, USA  
Pamela Bennett  
Ohio State University Extension, Springfield, OH, USA

**Objectives:** Capture NICH progress to date. Explore examples where interdisciplinary collaborations have produced significant results for Consumer Horticulture (CH) research. Explore the potential for consumer horticulture research. Facilitate discussion of ways to make connections and open doors for CH research.

**Description:** The National Initiative for Consumer Horticulture (NICH) is a diverse consortium of leaders who provide a unified voice for promoting the benefits and value of horticulture. NICH endeavors to unite national research efforts with the goals of the diverse stakeholders in the industry, the public sector, and the gardening public in an effort to advance knowledge and increase benefits and application of horticulture for cultivating a healthy world through landscapes, gardens, and plants and an improved quality of life. In the 2017 workshop, a review was presented of research related to the economic, environmental, and community and health benefits of CH. Following that review, this workshop offers opportunity to discuss strengthening CH research. The 2018 workshop will begin by exploring examples of CH research, collaborators, and strategies for reaching out to other disciplines. The latter half of the workshop will use facilitated discussion to identify ways to improve future CH research. Workshop attendees will rotate through stations to contribute to the discussion of questions, such as what are CH research goals? What can CH researchers do to strengthen our research? With whom should CH collaborate to achieve research goals? How do CH researchers meet these people? How do CH researchers have the conversation with other researchers? Attendee contributions will be captured on flip charts as well as by designated listeners so that the information can be compiled and reviewed and action steps identified.

2:45 PM – 3:00 PM

**Placing Horticulture within the Human/Nature Discussion**

Natalie Bumgarner*  
University of Tennessee, Knoxville, TN, USA

Human interactions with the natural environment have been shown to impact health, well-being, and mental function in a range of ways. Researching and then practically integrating the benefits of the natural experience for individuals and societies connects a number of fields that often include urban planning, environmental and natural resource economics, resource management, landscape design, and psychology. As urbanization continues, many of the frequent and everyday connections between humans and nature will increasingly occur in domains where consumer horticulture practitioners and educators play a key (and often leading) role. From urban parks, greenways, and greenspaces, to public gardens and arboreta, consumer horticulture practitioners guide or influence many of the most common human interactions with the soil, water, and plant elements of nature. This presentation will focus on opportunities and facilitated discussions around developing and strengthening research and outreach collaborations with those in natural resources and environmental psychology as well as urban planning.

3:00 PM – 3:15 PM

**Rethinking Food and Nutrition**

Esther E. McGinnis*  
North Dakota State University, Fargo, ND, USA

In order to thrive, consumer horticulture must be nimble and seek out far-reaching interdisciplinary research collaborations to expand beyond traditional paradigms. From the consumer perspective, progress on food and nutrition issues has suffered as the majority of horticultural funding and resources promotes breeding and production of food crops with commercial traits such as increased yields, plant disease-resistance, and specific food processing traits. Traits that benefit consumers, such as enhanced flavor and nutrition in horticultural crops, have been neglected. This session will focus on cultivating research relationships to fill this gap. Examples of large and small collaborations will be discussed, including the relationships that an award-winning
chef built with land grant universities to breed vegetables and grains with outstanding flavor, texture, and nutritional qualities to benefit restaurant patrons as well as home gardeners.

3:15 PM – 3:30 PM

**Considering Consumer Horticulture in the Human Health Realm**

Sheri Dorn*
University of Georgia, Griffin, GA, USA

Horticulture has been used for therapeutic purposes for more than 100 years, though scientific understanding of how and why it is so effective for human healing and well-being is relatively new. The dramatic increase in health care costs in recent years has provided incentive to more fully explore consumer horticulture’s impact on or role in physical and psychological health at the individual and community level. This presentation provides opportunity to discuss how horticulture can play a prominent role in the research and outreach collaborations with those contiguous to the human health realm, including medical doctors, therapists, psychologists, and human ecologists. It offers us a way to take a fresh look at the profession and practice of consumer horticulture and its influence on the ways in which we live and interact.

3:30 PM – 3:45 PM

**Strengthening Consumer Horticulture Research (Facilitated Discussion)**

Pamela Bennett*
Ohio State University Extension, Springfield, OH, USA

The latter half of the workshop will use facilitated discussion to identify ways to improve future Consumer Horticulture (CH) research. Workshop attendees will rotate through stations to contribute to the discussion of questions, such as what are CH research goals? What can CH researchers do to strengthen our research? With whom should CH collaborate to achieve research goals? How do CH researchers meet these people? How do CH researchers have the conversation with other researchers? Attendee contributions will be captured on flip charts as well as by designated listeners so that the information can be compiled and reviewed and action steps identified.

Thursday, August 2, 2018

*CEU Approved*

**Application of New Breeding Technologies for Improving Horticultural Crops**

*Coordinator:* Guo-Qing Song
Michigan State University, East Lancing, MI, USA

*Moderators:* Sanjun Gu
North Carolina Agricultural and Technical State University, Greensboro, NC, USA

Youping Sun
Department of Plants, Soils, and Climate, Utah State University, Logan, UT, USA

**Objectives:** Horticultural plant breeding is a process of genetic improvement for meeting various needs of growers and consumers. While traditional breeding technologies continue to be the foundation for crop improvement, advances in marker assisted breeding, next-generation sequencing, and genetic transformation in the recent past have revolutionized plant breeding and offered new and effective ways for plant breeders to manipulate traits at the levels of individual gene(s) or gene blocks. With the help of some of these technologies, virus-resistant papaya and squash have been widely commercialized and virus-resistant plum and non-browning apples, already deregulated by the U.S. Department of Agriculture, are on the horizon to be released. Recently, a new generation of breeding technologies emerges, such as transgrafting, MAB and fast-track breeding, cisgenesis/ intragenesis, and genome editing technologies; and several of them have proven very effective for solving problems that are otherwise difficult to combat with the existing breeding tools and technologies. This workshop invites experts to discuss recent progresses and future perspectives of these and other new breeding technologies for the improvement of horticultural plants, with an emphasis on commercial fruit crops.

**Description:** Genetic engineering (GE) provides powerful tools to improve fruit quality and productivity. This workshop, co-sponsored by Working Group of Asian Horticulture (WGAH) and Plant Biotechnology Group (BTCH), focuses on potential strategies that can be used to increase “fruit productivity”. Five invited speakers will lead the following discussions:

- **Genome editing technologies:** How can genome editing technologies be used to effectively manipulate fruit development process?
- **Cell engineering for fruit breeding:** What are new findings on using somatic hybrids for non-GE fruit breeding?
- **Tree architecture manipulation:** How can genetic manipulation of fruit tree architecture be achieved?
- **Genomics:** What has been revealed about the mechanism of self-incompatibility by genome sequencing?
- **New strategies for high yield:** What is the potential for yield increase by manipulating flowering pathway genes?

These discussions will highlight the potential and practicalities of utilizing new biotechnology strategies for the improvement of horticultural plants.

8:00 AM – 8:20 AM

**Efficient Genome-editing of Wild Strawberry Genes for Fruit Development**

Zhongchi Liu*
University of Maryland, College Park, MD, USA

The clustered regularly interspaced short palindromic repeats (CRISPR)-Cas9 system is an effective genome editing tool for
Recent Advances in Our Understanding of Self-incompatibility Mechanism in Prunus from a Genome-wide Analysis

Takuya Morimoto*
Kyoto University, Kyoto, Japan

Most rosaceous fruit tree species, such as plum, cherry, apple, and etc., show self-incompatibility (SI). SI hinders efficient breeding and cultivation in these fruit tree species. Three plant families Rosaceae, Solanaceae and Plantaginaceae share the common SI system called the S-RNase-based gametophytic SI, which uses S-RNase and F-box protein as the specificity determinants in pistil and pollen, respectively. Although similar molecules are involved in specificity determination in SI recognition reaction across different taxa, accumulated data suggests the presence of distinct SI recognition mechanisms. While the pistil S determinant S-RNase is considered to have a cytotoxic effect against pollen tube RNA in the Rosaceae, Solanaceae and Plantaginaceae, the pollen S determinant F-box proteins are suggested to have different functions in genus Prunus and in the other taxa that show the S-RNase based SI. Pollen S in Prunus is assumed to release cytotoxicity of self S-RNase, while in the other taxa, pollen S is considered to be involved in S-RNase detoxification. Since the genome sequence information from various plant taxa has been available, we are now able to utilize new approaches such as evolutionary analysis and genome re-sequencing to uncover molecular mechanism of SI. Here, we summarize recent advances in our understanding of SI mechanism in Prunus based on the genome-wide analyses.

8:40 AM – 9:00 AM

Biotechnological Approaches to Increase Fruit Productivity—A Case Study on Blueberries

Guo-Qing Song*
Michigan State University, East Lansing, MI, USA

Blueberries contain high amounts of antioxidants known to be important for human health. Developing new cultivars with different chilling requirement, high cold/heat tolerance, and high yield are the top priorities in blueberry breeding due particularly to the anticipation of climate changes. This presentation will focus on biotechnological approaches to increase productivity of blueberry. Overexpression of a blueberry DWARF AND DELAYED FLOWERING 1 increased freezing tolerance without a trade-off impact on plant growth. Transgenic blueberries overexpressing a blueberry FLOWERING LOCUST (VcFT) were produced and will facilitate FAST-TRACK blueberry breeding. Transgrafting on VcFT-overexpressing blueberry plants promoted floral bud formation in nontransgenic scions, and it provides a new approach to increase blueberry yield. Overexpression of the K-domain of a blueberry SUPPRESSOR of Overexpression of Constans 1 gene increased berry productivity through the interaction of MIKC-MADS-box genes. Transcriptome analyses in transgenic and non-transgenic blueberries revealed cold-regulated genes and flowering pathway genes. These studies suggest that manipulation of flowering pathway gene(s) is powerful to increase blueberry productivity.

9:00 AM – 9:20 AM

Cell Engineering and Citrus Genetic Improvement in China

Wen-Wu Guo*
Huazhong Agricultural University, Wuhu, China

Citrus is the most important fruit crop in the world and in southern China. Cell engineering holds great potential for citrus genetic improvement. In our program, somatic hybrids from over 50 interspecific and intergeneric fusion combinations were produced which efficiently circumvented the reproductive barriers such as nucellar polyembryony, male/female sterility encountered in citrus conventional breeding. Numerous autotetraploids, haploids and dihaploids were also produced and identified by SSR markers. Metabolic adaptation following genome doubling in citrus doubled diploids was revealed by non-targeted metabolomics. Some somatic hybrids / autotetraploids already flowered and set fruits, and served as pollen parents for seedless triploid production resulting in thousands of triploid plants from over 50 ploidy crosses being recovered and identified by embryo rescue, flow cytometry and SSR analysis. Facilitated by molecular marker analysis of numerous citrus somatic hybrids and cybrids, a strategy of male sterile cybrid production by symmetric fusion between embryogenic callus protoplasts of Satsuma mandarin (CMS type with sterile cytoplasm) and mesophyll protoplasts of elite seeded cultivars were put forward, and diploid cybrid plants containing sterile...
cytoplasm from Satsuma were regenerated, some cybrids already showed male sterility and seedless traits. The mechanism of male sterility in a citrus somatic cybrid is being conducted. Cell engineering combined with application of molecular marker and omics technology greatly enhanced the efficiency and targeted breeding of citrus cell engineering research.

9:20 AM – 9:40 AM

**Genetic Manipulation of Fruit Tree Architecture to Enable High-density Production Systems**

Courtney A. Hollender*
Michigan State University, East Lansing, MI, USA
Chinnithambi Srinivasan

Ralph Scorza
Sheperdstown, WV, USA

Chris Dardick
Appalachian Fruit Research Station, USDA-ARS, Kearneysville, WV

Tree fruit production has been increasingly moving toward high density orchards. This is change is being driven by a need to increase production with limited resources, including labor. Most fruit trees, however, aren’t naturally amenable to high density growth. The use of dwarfing rootstocks has been essential for the success of high density apple plantings. However, many fruit tree species lack size-controlling and dwarfing rootstock. In addition, time consuming branch training, scoring, and growth regulator applications are also needed for high density production. This amount of labor isn’t practical for some species. Fortunately, fruit tree germplasm collections contain trees with more amenable architectures, including smaller statures and growth habits with potentially beneficial shoot orientations. Technological advances, such as high throughput sequencing, have enabled the genetic causes for these traits to be identified. Coupling this ability with improvements in tree transformation and gene editing can enable generation of newer cultivars and cultural practices that could make high density orchards a reality for more fruit species. The recent identification of genes associated with non-standard peach architectures exemplify this advancement. Mutations in the TAC1 gene were found to be the cause pillar or columnar growth habits in peach. The repression of this gene in plum led to slender pillar plums, which can be planted closer together than standard plums. In addition, the overexpression of TAC1 also resulted in plums with wide branch angles. Wide angles can cause plagiotropic growth, which is desirable for trellis-based high density systems. The identification of TAC1 also led to the identification and manipulation of a related plum gene, LAZY1. Reduction in LAZY1 expression in plum resulted in trees also produced trees with wider branch angles. Other examples of the utility of gene identification and manipulation include the modulation of GID1c expression. A mutation in GID1c is the cause of dwarf peach phenotype, and reducing the expression level of this gene in plum produced dwarf and semi dwarf trees. Taken together, these results illustrate the possibility for rapidly breeding trees specific for high density stand alone and trellis-based plantings, which are needed for the tree fruit production sustainability in the future.

*CEU Approved*


**Coordinators:** Chengyan Yue
University of Minnesota, St. Paul, MN, USA

Bridget Behe
Michigan State University, East Lansing, MI, USA

**Moderator:** Chengyan Yue
University of Minnesota, St. Paul, MN, USA

**Objectives:** This workshop explores the issues related to sustainability in consumer horticulture. Presentations will feature an understanding of the issues surrounding various sustainable practices (aquaponics, recycling, sustainable irrigation systems, etc.) and consumer preferences for and attitudes toward sustainability.

**Description:** This workshop explore and discuss the issues related to sustainability in consumer horticulture. Presentations will feature an understanding of the issues surrounding various most recent sustainable trends and practices (aquaponics, recycling, sustainable irrigation systems, etc.) and the market potential and consumer preferences for sustainability. Consumer demand for sustainable products and business practices continues to rapidly rise. Many eco-consumers are profitable to companies that appeal to them with a record of environmentally friendly or sustainable production practices because eco-friendly products and practices can garner a higher price premium. Sustainable practices are being adopted by horticultural businesses such as using recycling water, aquaponics production system, sustainable irrigation systems, and etc., yet the communication of many products and practices is languishing. It is imperative to both study and communicate the market potential for eco-friendly products and practices. Consumers’ attitudes toward sustainably-produced products or production practices may vary significantly due to a wide variety of factors. This workshop will explore the market potential for these recent practices in sustainability and compare consumer attitudes and preferences across different fields and products. Specifically, consumer preferences and willingness to pay for produce grown in aquaponics production system are explored; homeowners’ preferences and willingness to pay for smart irrigation controllers are investigated; consumer acceptance of recycled water are assessed; and how information source affect consumer preferences for plants with environmental labeling are studied. A discussion will follow each presentation. At the end of all the presentations, a more comprehensive group discussion will be facilitated to engage workshop participants, discuss what sustainability means for the horticultural industry, and explore future research ideas surrounding sustainability.
Workshops

8:00 AM – 8:15 AM

**Consumer Preferences for Aquaponically-grown Produce: Implications from Experimental Auctions and Market Segmentation Analysis**

Chengyan Yue*
University of Minnesota, St. Paul, MN, USA

Neil Anderson
University of Minnesota, St. Paul, MN, USA

Marie Sorensen
University of Minnesota, St. Paul, MN, USA

Gianna Short
University of Minnesota, St. Paul, MN, USA

8:15 AM – 8:30 AM

**The Effect of Priming Messages on Consumer Perceptions of Recycled Water**

Bridget Behe*
Michigan State University, East Lansing, MI, USA

Nikki McClaran
Michigan State University, East Lansing, MI, USA

Patricia Huddleston
Michigan State University, East Lansing, MI, USA

Charles Hall
Texas A&M University, College Station, TX, USA

8:30 AM – 8:45 AM

**Preferences and Willingness to Pay for Sustainable Landscape Irrigation Systems**

Hayk Khachatryan
University of Florida, Apopka, FL, USA

Alicia Rihn*
University of Florida, Apopka, FL, USA

8:45 AM – 9:00 AM

**Information Source and Purchasing of Plants with Environmental Labeling**

Ben Campbell*
University of Georgia, Athens, GA, USA

Julie Campbell
University of Georgia, Athens, GA, USA

*CEU Approved*

**Plant Nutrition Diagnostics**

*Coordinators:* Robert Mikkelsen
International Plant Nutrition Inst, Merced, CA, USA

Kent Kobayashi
University of Hawaii at Manoa, Honolulu, HI, USA

*Moderator:* Robert Mikkelsen
International Plant Nutrition Inst, Merced, CA, USA

Objectives: Proper management of plant nutrients has economic, environmental, and social impacts. New diagnostic tools are continually being developed to allow horticulturists to improve their use of both inorganic and organic nutrient sources. This workshop demonstrates new approaches and techniques for predicting plant nutrient requirements, assessing nutritional adequacy, and diagnosing nutritional problems that arise during the growing season. Tools and methods for field evaluation and for laboratory diagnosis will be available during the workshop. Attendees will learn about the latest science in predicting and measuring nutrient adequacy.

Description: Predicting and assessing the adequacy of mineral nutrition for plants has important economic and environmental implications. New tools and modern approaches assist growers to appropriately use both inorganic and organic nutrient sources. This workshop reviews and demonstrates modern equipment and techniques for making in-field and laboratory assessments plant nutrient status.

10:15 AM – 10:30 AM

**The Importance of Proper Plant Nutrition**

Robert Mikkelsen*
International Plant Nutrition Inst, Merced, CA, USA

This presentation will cover the economic, environmental, and social needs for proper plant nutrient management. This introductory session will provide global context to plant nutrition for maintaining high yields and quality of horticultural crops.

10:30 AM – 10:50 AM

**Assessing Plant Nutrient Status during the Growing Season: Laboratory Tools**

TBD*

Monitoring the nutrient status of horticultural crops during the growing season provides valuable information regarding plant health. A hands-on demonstration will be made of proper tissue sampling, petiole extraction and analysis, and destructive sampling techniques. The analytical process of working through a certified laboratory to achieve reliable results will be demonstrated by showing inter-lab variation. A virtual tour of a working plant analysis laboratory will be presented as part of the workshop.

10:50 AM – 11:10 AM

**Predicting Nutrient Adequacy with Soil Testing: New Approaches**

Bruce Dunn*
Oklahoma State University, Stillwater, OK, USA

Soil testing can provide a valuable prediction of the nutrient requirement of horticultural crops. Although soil testing has been used for many years, there are still many spatial and temporal issues related to soil sampling. Laboratory analysis of the samples
should be done by organizations participating in a certification program. Interpretation of the analytical results that result in fertilizer recommendations are also weak for many important horticultural crops. Demonstration of various tools for soil/media sampling, new resin-based root simulators, and a virtual tour of a modern soil testing lab will be included in the workshop.

11:10 AM – 11:30 AM

Assessing Plant Nutrient Status during the Growing Season: In-field Tools
Bruce Dunn*
Oklahoma State University, Stillwater, OK, USA

There are a variety of new non-destructive methods for assessing the nutrient status of horticultural crops. Destructive methods are expensive, relatively time consuming, and rely on laboratory analysis. Non-destructive methods are rapid and less expensive, but may be less accurate. There are many field and remote sensing techniques that are now available for assessing plant nutrient status. A variety of commercially sensors will be discussed and demonstrated during the workshop. Attendees will have hands-on demonstrations with several of these sensors and learn how they operate.

11:30 AM – 11:45 AM

Tools for Visual Diagnosis of Nutrient Sufficiency
Dharma Pitchay*
Tennessee State University, Nashville, TN, USA

Visual diagnosis of plant nutrient deficiency symptoms can provide valuable information on crop health. Many of the essential plant nutrients have distinct deficiency symptoms that can be used as a guide for correcting nutrient shortages. However, when symptoms become visible, the crop has already been subject to hidden nutrient deficiency. Symptoms can also be caused by biotic and abiotic issues, making diagnosis frequently challenging. A variety of modern guides are now available to empower farmers to conduct field diagnosis of nutrient deficiency. Demonstration of modern tools for visual diagnosis of plant nutrient deficiency symptoms will be provided in the workshop.

*CEU Approved*

The Important Role of Horticulture in Conservation of Threatened and Endangered Plants

Coordinator/Moderator: Matthew Taylor
Longwood Gardens, Kennett Square, PA, USA

Objectives: The objectives of this workshop on the role of horticulture in conservation of threatened and endangered plants is to: 1) inform ASHS community on the important role horticulture plays in plant conservation programs around the globe and to improve synergy among researchers focused on plant conservation objectives and those focused on horticultural objectives. 2) Discuss where knowledge and resource gaps exist. 3) Determine methods to gain support and further engage ASHS members and the horticultural communities. 4) Create a list of action items to garner support for conservation from ASHS members. The workshop will also support key objectives of the worldwide initiative of the Global Strategy for Plant Conservation (GSPC).

Description: This Public Horticulture Public Interest Group sponsored workshop will showcase the ever-growing role of horticulture in plant conservation programs and work to develop action items to further connect horticulture and conservation programs. A high-level overview of global plant conservation followed by specific conversation efforts will showcase the important role of horticultural techniques and expertise. Seed germination, vegetative propagation, greenhouse and nursery production, ecosystem restoration, molecular analysis, tissue culture and cryopreservation are just some of the techniques that will be discussed as tools used for saving threatened and endangered plants. The first discussion will focus on identifying gaps between conservation efforts and the horticultural community. The second session will work toward developing action items to bridge gaps identified in the earlier discussion. Each discussion will begin with high level questions to promote an organic discussion, ultimately used to synthesize take-home points and action items.

10:15 AM – 10:20 AM

Overview of the Importance of Horticulture for Saving the Worlds Endangered Flora
Matthew Taylor*
Longwood Gardens, Kennett Square, PA, USA

The 2017 assessment by the International Union for Conservation of Nature (IUCN) indicates there are over 24,000 threatened plant species worldwide, which represents an estimated 6% of plant species. In North America, 4420 species are considered threatened. To confront the growing threat to plant biodiversity, Botanic Gardens Conservation International (BGCI) has established The Global Strategy for Plant Conservation (GSPC). The vision for the GSPC is to halt the continuing loss of plant diversity and to secure a positive, sustainable future where human activities support the diversity of plant life. Five objectives and 16 outcome-oriented targets have been implemented by GSPC and challenge humanity to participate. Particularly relevant to horticulture are the seven Targets of Objective II: Plant diversity is urgently and effectively conserved. This objective emphasizes in situ and ex situ conservation efforts, ecological restoration, and invasive plant management. In many cases, horticultural techniques and expertise are integral to the success of these efforts. Many public gardens, universities, non-profits, private organizations, and businesses are already working toward accomplishing these targets. However, much more work is needed. The all-important role horticulture in these outcome-oriented targets is the beckoning for horticulturist from around the world to do their part in preventing the loss of plant biodiversity.

An asterisk (*) in front of a name indicates the presenting author.
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10:20 AM – 10:30 AM

**Horticulture As a Necessary Partner to Land Preservation When Conserving Endangered Plants**

David Remucal  
Minnesota Landscape Arboretum, Chaska, USA

Kimberly Drewiske*  
Minnesota Landscape Arboretum, Chaska, MN, USA

Land preservation has been the primary means of endangered plant conservation for many years. As we continue to lose species there is an increasing recognition of the need for ex situ conservation techniques to complement these in situ techniques. Ex situ conservation is generally gene banking, which can take many forms, seed banking being the most common, but can also include techniques such as tissue culture preservation or living off-site populations. Whatever the form, ex situ conservation is ultimately only going to be successful as a form of conservation if genetically diverse and ecologically/genetically appropriate plants can be grown and moved back onto natural landscapes, which is where horticulture is important. Horticultural techniques will also be important as land preservation groups seek to connect the fragmented genetics of land preserve “islands”. Both the techniques and the infrastructure of modern horticulture, especially those available at a public-forward institution like a botanic garden, would fit well with the ex situ conservation needs that land preservation alone does not meet. Of particular note are the technology and data tracking botanic gardens often have available, which are vital tools to help track and manage genetics. As climate change continues and static land preserves change to different ecotypes we will need to have a system in place to help plants migrate to new, and newly appropriate, locations. Horticulture and botanic gardens are the logical choice for these systems and are in many cases already preparing for this work.

10:30 AM – 10:40 AM

**Accelerated Ex Situ Conservation of Threatened Magnolia Species Using Commercial Nursery Propagation and Production Methods**

Gary Knox*  
University of Florida, Quincy, FL, USA

Of the 244 threatened (CR, EN, VU) or data deficient (DD) Magnolia species cited in *The Red List of Magnoliaceae, revised and extended*, (Rivers et al., 2016), only 104 (43%) can be found in *ex situ* collections. Most of these are present in five or fewer collections resulting in a greater risk of loss. Modern nursery propagation and production methods may be employed to propagate and rapidly grow endangered magnolias that can then be distributed for widespread ex situ conservation. *Magnolia sphaerantha* (C.Y.Wu ex Y.W.Law & Y.F.Wu) Sima (syn. *Magnolia elliptilimba*, *Michelia sphaerantha*), ranked data deficient, is a rare species of evergreen magnolia that grows as a medium tree in broadleaved evergreen forests at elevations of about 2000 m in central Yunnan Province, China. Until recently it was rarely found in botanical gardens outside China. In early 2014, the UF/IFAS NFREC received 66 seeds collected Nov. 2013 from a grove of wild-collected *M. sphaerantha* in Kunming Botanical Garden, Yunnan, China. Twenty seeds germinated and seedlings were cultivated using production methods typical of North American container nurseries, including applications of slow release fertilizer and automatic irrigation to plants growing in containers containing soilless substrate. Rapid seedling growth resulted, allowing repeated collections of axillary cuttings for asexual propagation. Cuttings 12-14 cm in length were treated with a commercial tale-based rooting hormone and placed in a greenhouse under intermittent mist. Cuttings rooted in 9-11 weeks at percentages ranging up to 100% depending on seedling clone and rooting hormone concentration. In addition, rapid growth of newly propagated plants allowed additional cuttings to be collected from the initial set of propagules. Within 12 months of initial seed collection, parent seedlings exceeded 2 m in height and a total of 114 *M. sphaerantha* plants were available for distribution. As a result of these efforts, *M. sphaerantha* specimens are in *ex situ* cultivation at 32 botanical gardens and other institutions in 13 North American states and provinces. Similar nursery production and propagation practices are being applied to *M. garrettii*, *M. rajaniana*, and *M. sapaensis*. Preliminary research demonstrated feasibility of cutting propagation from seedlings of *M. fraseri* var. *pyramidata*, a taxon which cannot be propagated by cuttings from mature growth.

10:40 AM – 10:50 AM

**Strategies to Conserve Magnolia ashei Based on Molecular Diversity Analysis**

Christopher Von Kohn  
USDA-ARS U.S. National Arboretum, Beltsville, MD, USA

Kevin Conrad  
USDA-ARS U.S. National Arboretum, Beltsville, MD, USA

Matthew Kramer  
USDA-ARS, Beltsville, MD, USA

Margaret Pooler*  
USDA-ARS, U.S. National Arboretum, Beltsville, MD, USA

The Ashe magnolia (*Magnolia ashei*) is a deciduous small tree most noted for its large leaves and fragrant white flowers. Although the species is adapted to and used in landscapes in many parts of the United States, it is endemic only to Northwest Florida where it is limited to ten counties growing on undisturbed bluffs and ravine banks. The populations are highly fragmented and are threatened by degradation of habitat, leading the species to be listed as endangered in the state of Florida. The SSR markers were developed to determine the genetic diversity of wild populations of *M. ashei* in order to guide long-term conservation strategies. 18 marker loci identified a total of 82 alleles that were used to characterize allelic diversity of *M. ashei* from 11 wild populations, 14 cultivated sources, three interspecific hybrids. Results indicated a higher than expected level of heterozygosity within populations, and a clear distinction between Eastern and Western races. Preliminary molecular diversity research on *Magnolia macrophylla* and a hybrid of *M. garrettii* x *M. rajaniana* indicates that fine scale population structure might be important for long-term protection strategies.
and Western populations; conservation efforts should therefore focus on maintaining these distinct groups in corresponding ex situ seed orchards to counteract pressures due to overcollection, pollution, and loss of habitat due to development. Clustering of individuals was similar using several analytical methods, indicating that despite relatively small sample sizes, our analysis is an accurate reflection of the diversity among and relationships between these populations.

10:50 AM – 11:00 AM

**Gap Analysis Discussion: What are the Primary Barriers That Need to Be Overcome to Garner Support from More ASHS Members and the Horticultural Community for Plant Conservation Initiatives?**

Matthew Taylor*
Longwood Gardens, Kennett Square, PA, USA

11:00 AM – 11:10 AM

**Plant Cryopreservation at the Huntington Botanical Gardens**

Raquel Folgado*
The Huntington Library, Art Collections and Botanical Gardens, San Marino, CA, USA

Besides the in situ conservation of plants, the development of efficient methods of ex situ conservation plays a crucial role in the maintenance of plant biodiversity. However, the traditional preservation methods, such as field clonal genebanks, are often costly and risky. Most of the plants are usually propagated through seeds, grafting, and rooting of stem cuttings. However, these methods are not always highly efficient for obtaining a significant amount of disease-free plant material that might be used to re-introduce the plants in the natural environment if needed. An appropriate approach is the use of micropropagation (or tissue culture) to maintain additional ex situ collections besides the field collections at botanical gardens, such as The Huntington. Furthermore, we can take advantage of innovative techniques which allow long-term conservation of plants, such as cryopreservation or the storage of plant material from tissue culture at an ultra-low temperature (−196 °C, in liquid nitrogen). The primary goal of the cryopreservation program at The Huntington Botanical Gardens is providing protocols to preserve plant germplasm in liquid nitrogen and freezers. This technology will help to ensure long-term conservation for threatened species that are part of living collections at botanical gardens, such as The Huntington. We are working with succulents, cacti, magnolias, avocado, oaks and other endangered species.

11:10 AM – 11:20 AM

**Native Orchids—Potential Uses in Horticulture in Support of Conservation**

Dennis Whigham*
Smithsonian Environmental Research Center, Edgewater, MD, USA

The Orchidaceae is recognized as one of the most species-rich plant families on earth and it is also recognized that many native orchids are threatened, for example, by over-harvesting, climate change, and habitat destruction. The North American Orchid Conservation Center (NAOCC) has been established to conserve the genetic diversity of native orchids in the United States and Canada, with a long-term goal of using an ecological approach to conserve native orchids globally. A pillar of the NAOCC model for conservation is propagation of native orchids from seed using appropriate mycorrhizal fungi. Horticulture is envisioned to play an important role in the effort to conserve native orchids. Many native orchids have the potential to be used in horticulture and successful propagation in formal and informal garden settings will result in the establishment of native orchid populations in support of efforts to restore species across the United States and Canada. The application of ecological principles to orchid conservation will also raise awareness of the importance of orchid-fungal interactions — an essential component of native orchid ecology.

11:20 AM – 11:30 AM

**Determination of Asymbiotic, In Vitro Seed Germination, In Vitro Seedling Development and Greenhouse Acclimatization Protocols of Threatened Spiranthes Species for Ex Situ Conservation**

Peter Zale*
Longwood Gardens, Kennett Square, PA, USA

Reproducible propagation protocols are needed to develop genetically diverse ex situ collections of U.S. native orchids, but do not exist for many species of conservation concern. Approximately 45 species of the taxonomically difficult genus *Spiranthes* are found worldwide; 23 species occur primarily in the eastern United States and several are considered rare, threatened or endangered by federal and state agencies. Using the Pennsylvania endangered *Spiranthes casei* as a model species, a series of experiments were designed to determine optimal conditions for in vitro seed germination, in vitro seedling development and greenhouse acclimatization. Seeds were collected in Nov. 2015 from 10 individual plants found in three subpopulations in Elk and McKean counties, Pennsylvania, cleaned and air-dried for six weeks. Seeds were surface sterilized and scarified for 10 and three minutes in 10% bleach solution, then plated on five replicates each of three different commercially available terrestrial orchid seed germination media: P723, M551 and K400 (Phytotechnology Labs, Shawnee Mission, KS) with pH adjusted to 5.8. Seed germination ranged from 24 to 60% and occurred on all three media only after the 3-minute treatment; none of the seeds germinated after the 10-minute treatment and visual inspection revealed badly damaged embryos. After shoot initiation, 150 seedlings were transferred to individual test tubes on one of two media (P723 and P658) and each was given one of the three photoperiod treatments for 10 months: 24/0 h [light/dark (L/D)], 18/6 h L/D and 0/24 h L/D. Seedling survival and...
growth occurred in all treatments, but incubated on P723 in the 24/0 and 16/8 treatments had a significantly greater fresh weight, leaf length, number of roots and root length than light treatments on P658 and dark treatments, indicating that light is essential for optimal seedling growth. Seedlings were removed from the test tubes and given a 100-day vernalization period at 2 °C. Seedlings were then randomly planted in one of four soilless media (Longwood Gardens research mix (LGRM), New Zealand sphagnum (NZ), Fafard 3b and Good Earth BC5). The survival rate (95%) and highest incidence of flowering (20%) occurred on NZ. The lowest survival rate (55%) and incidence of flowering (10%) was on LGRM. Results support anecdotal evidence that *Spiranthes* seeds are degraded by extended chemical scarification times. The propagation techniques described above are being applied to additional *Spiranthes* species to determine the efficacy of the protocol for propagating a greater range of taxa. 

11:30 AM – 11:45 AM

**Using Points Identified during the Gap Analysis Discussion, This Session Will Be Utilized to Develop Action Items to Bridge Conservation Programs, ASHS, and the Horticultural Community**

Matthew Taylor*

Longwood Gardens, Kennett Square, PA, USA

An asterisk (*) in front of a name indicates the presenting author.
practice (business), and education. This workshop is set up in 3 parts. First, 10–12 synopses, each three minutes long, containing one slide, and collectively covering grafted plant preparation (beginning with rootstock-scion selection), use, and evaluation, will be shared by researchers and educators. Next, a moderated group-wide discussion will demonstrate how participants can immediately gain and contribute to the science and practice of vegetable grafting. Finally, a supplementary, interactive, multimedia, and hands-on session will demonstrate and portray hand and machine assisted vegetable grafting techniques. Workshop participants will gain: a) greater familiarity with the U.S.-based vegetable grafting-related scientific and industry community; b) a shared understanding of the current application of vegetable grafting in commercial and consumer horticulture and education; c) up-to-date information on current and emerging vegetable grafting-related hypotheses, experiments, recommendations, resources, and techniques; and d) foundations for plans representing independent and collaborative efforts to follow up on insights gained during the workshop.

1:50 PM – 1:55 PM
**Evaluating Desirable Root Traits for Chill-tolerant Tomato Rootstocks for Early Plantings in Northern Nevada**
Felipe Barrios Masias*
University of Nevada, Reno, NV, USA

1:55 PM – 2:00 PM
**Addressing the Needs for Developing Management Programs Toward Optimizing Grafted Vegetable Performance and Cost Effectiveness**
Xin Zhao*
University of Florida, Gainesville, FL, USA

2:00 PM – 2:05 PM
**Research and Outreach on Grafted Tomatoes Directed to Non-commercial Producers in the Southeast**
Natalie Bumgarner*
University of Tennessee, Knoxville, TN, USA

2:05 PM – 2:10 PM
**Increasing Organic Cucumber Yield By Grafting and Keeping Two Leading Vines in a High Tunnel**
Sanjun Gu*
North Carolina Agricultural and Technical State University, Greensboro, NC, USA

2:10 PM – 2:15 PM
**Opportunities of Growing Grafted Seedless Cucumbers for Greenhouse and High Tunnel Production in the Midwest**
Wenjing Guan*
Purdue University, Southwest Purdue Agricultural Center, Vincennes, IN, USA

2:15 PM – 2:20 PM
**Light and Temperature Requirements for Growing Consistent Rootstock and Scion Material for Cucurbit Grafting**
Richard Hassell*
Clemson University, Charleston, SC, USA

2:20 PM – 2:25 PM
**Morphological Responses of Scion ‘Florida 47’ and Rootstock ‘Shin Cheong Gang’ Tomato Seedlings to Varied Light Intensity and CO₂ Enrichment**
Brandon M Huber*
North Carolina State University, Raleigh, NC, USA

2:25 PM – 2:30 PM
**Vegetable Grafting from the Perspective of Tri-Hishtil**
Josh Kardos*
Ashville, NC, USA

2:30 PM – 2:35 PM
**Integration of Industrial and Systems Engineering Approach in Optimizing Nursery Operations for Vegetable Grafting**
Chieri Kubota*
Ohio State University, Columbus, OH, USA

2:35 PM – 2:40 PM
**Increasing Access to and Application of Vegetable Grafting**
Carol Miles*
Washington State University, NWREC, Mount Vernon, WA, USA

2:40 PM – 2:45 PM
**Grafting As a Means to Improve Vegetable Fruit Quality and Storage Life**
Penelope Perkins-Veazie*
North Carolina State University, Kannapolis, NC, USA

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An asterisk (*) in front of a name indicates the presenting author.
Opportunities in Organic Watermelon Production Systems Utilizing Disease Resistant Scion and Rootstock Combinations
Brian Ward*
Clemson University CREC, Charleston, SC, United States

Introduction of Grafted Transplanting Industry and Academic Research in Korea
An Se Woong*
Vegetable Science Division, National Institute Horticultural & Herbal Science, Wanju, Korea, Republic of (South)

Discussion

*NIFA National Research Support Project 10: Specialty Crop Database Resources for Genomics, Genetics and Breeding Research
Coordinator: Doreen Main
Washington State University, Pullman, WA, USA
Moderator: Mike Kahn
Washington State University, Pullman, WA, USA

Objectives: The objectives of this workshop are to: 1) update NRSP10 participants and other specialty crop researchers on new development of specialty crop genomic, genetic and breeding community database resources; 2) provide specialty crop researchers with outline of plans for the next five years of this project; and 3) solicit feedback from the community on database and tool development needs and extension activities associated with this project.

Description: National Research Support Project 10 (<NRSP10, www.nrsp10.org>) is a USDA NIFA funded, five year project (2014–19) providing national crop database resources for underserved crops with a focus on specialty crops. It involves broad support and participation from U.S. Land Grant Universities Experiment Stations and industry, many of who will present updates of project features or be participants in this follow up workshop to the one held at ASHS 2017. It will be will include a series of talks by scientists who use these rosaceae (<www.rosaceae.org>), citrus (<www.citrusgenomedb.org>), and vaccinium (<www.vaccinium.org>) database resources to enable their genomics, genetics and breeding research, highlight new data and functionality, present ideas for further work and solicit feedback from the workshop attendees.

Example questions for the participants might include:
- Do you need help with setting up a project database using Tripal or do you see using your community database as able to meet your project data management and project data sharing and analysis needs?
- What challenges or impediments do you have or forsee having in your ability to use the FieldBook App to collect phenotype data from the field?
- Do you see your program as being able to utilize global prediction functionality and if so what might be the challenged your would face in using it?
- Is there any functionality you need in these databases that we don’t have? If so, is that functionality available in other databases?
- Do you like the functionality of BIMS? What can we do or provide to help you be able to use it? Any limitations you can see with it?
- Do the planned activities for the next five years look appropriate? Are there other activities we should be including and if so what are they?
- Is it clear what these database resources and tools provide to you? What are we doing well in this project and where are we not doing well and could improve? Should NRSP10 have a larger role in educating young scientists on data management, data nomenclature, data submission to maximize possible re-use and impact of their research data and results?

Welcome and Goals of NRSP10 Workshop
Mike Kahn*
Washington State University, Pullman, WA, USA

In the introduction to the workshop, we will go over the aims of the workshop and briefly introduce NRSP10.

Tripal v3, the Collaborative Online Database Platform Supporting an International Community of Plant Genome Databases
Margaret Staton*
University of Tennessee, Knoxville, TN, USA
Abdullah Almsaeed
University of Tennessee, Knoxville, TN, USA
Bradford Condon
University of Tennessee, Knoxville, TN, USA
Ming Chen
University of Tennessee, Knoxville, TN, USA
Jill Wegrzyn
University of Connecticut, Storrs, CT, USA
Emily Grau
University of Connecticut, Storrs, CT, USA

An asterisk (*) in front of a name indicates the presenting author.
Tripal is an open-source software platform for building online community or project databases that house genes, genomes, markers, germplasm, genotypes, phenotypes and other data types. A number of specialized community databases that use Tripal are tailored for horticultural and agricultural crops such as fruits, nuts, legumes, cotton, and forest trees. With active code contributors from eight research groups in three countries, Tripal has emerged as a model of cooperative database development across specialty crops and as a mechanism for increased sustainability of community-level and community-built web resources. Based on the content management system Drupal, Tripal enables developers to easily write their own custom code and share with others. The community is building the primary infrastructure to support standardized biological data storage formats, intuitive data visualization, and commonly needed analysis tools. With increasing maturity of the software and a growing number of member databases, Tripal is now poised to take advantage of the shared code base across groups by building cross-site interfaces that unify data across various specialty crop communities. This is largely enabled by the latest version of Tripal v3, a fully ontology-driven design with data structures and RESTful web services. With the new major expansion of the Tripal module that leverages ElasticSearch, sites are able to provide comprehensive full text search to users and also incorporate search results from other public Tripal databases. For example, the Hardwood Genomics Project can return relevant search results from its own data stores as well as results from other sites with tree data such as TreeGenes, the Genome Database for Rosaceae, and the Citrus Genome Database. The growth of the Tripal community demonstrates how to drive advances in large scale cyberinfrastructure development and data integration through collaborations among smaller, specialized research communities.

2:05 PM – 2:20 PM

New Data and Functionality in NRSP10 Databases

Sook Jung*
Washington State University, Pullman, WA, USA

Taein Lee
Washington State University, Pullman, WA, USA

Chun-Huai Cheng

An asterisk (*) in front of a name indicates the presenting author.
and US Land Grant Universities funded project which provides standardized database and informatics resources for underserved or specialty crops such as tree fruit, nuts, and berries. It builds on existing database resources developed for Rosaceae (Genome Database for Rosaceae, www.rosaceae.org), Citrus (Citrus Genome Database, www.citrusgenomedb.org), Vaccinium (Genome Database for Vaccinium, www.vaccinium.org), Cool Season Food Legumes (Cool Season Food Legume Genome Database, www.csfl.org) and Cotton (CottonGen, www.cottongen.org). Developed using Tripal, an open-source, resource-efficient, modular, well supported software platform, these community databases provide centralized access to integrated genomic, genetic and breeding data and analysis tools for 24 crops representing a combined annual production value of over $25 B. The latest data and functionality provided in these databases includes integrated genomic, genetic and breeding data made accessible through various search pages, JBrowse, and the new interactive visualization tools such as TripalMap for genetic maps and Tripal Synteny Module for browsing conserved syntenic blocks among genomes. We will also highlight access to available public data through the new Breeding Information Management System (BIMS), a resource being developed for breeders to manage, store, and analyze their private breeding data integrated with public data in these databases.

2:20 PM – 2:35 PM

Integrating Free Mobile Apps into Specialty Crop Breeding and Horticultural Programs

Trevor Rife*
Kansas State University, Manhattan, KS, USA

Jesse A. Poland
Kansas State University, Manhattan, KS, USA

Plant breeding, horticultural, and genetics research are inherently data-driven enterprises. Typical experiments and breeding nurseries can contain thousands of unique entries and programs will often evaluate tens of thousands of plots or plants each year. Due to temporal and economic limitations, many phenotypes that could prove useful for selection are neglected or collected only on a subset of lines. To operate a modern breeding program efficiently, electronic data capture and management is essential. Many research programs, however, continue to operate by scribing and transcribing much, if not all, of their data. This creates a heavy burden on human resources, decreases data integrity, and limits future utilization of data. We have developed several open-source apps to increase the speed and robustness of data collection in plant breeding programs. All of our apps run on consumer-grade Android phones and tablets, thereby decreasing the cost to breeders and creating a viable solution for research programs around the world. In this presentation, we will briefly introduce our collection of apps that are relevant to specialty crop phenotype data collection but focus on Field Book, an app for field and greenhouse data collection and highlight improvements made following input from specialty crop breeders through the NRSP10 project.

2:35 PM – 2:50 PM

Using the Tripal Breeding Information Management System to Improve Breeding Efficiency

Ksenija Gasic*
Clemson University, Clemson, SC, USA

Taein Lee
Washington State University, Pullman, WA, USA

Sook Jung
Washington State University, Pullman, WA, USA

Jodi Humann
Washington State University, Pullman, WA, USA

Jing Yu
Washington State University, Pullman, WA, USA

Heidi Hough
Washington State University, Pullman, WA, USA

B. Todd Campbell
USDA-ARS, Florence, SC, USA

Cameron Peace
Washington State University, Pullman, USA

Kate M. Evans
Washington State University, Tree Fruit Research and Extension Center, Wenatchee, WA, USA

Dorrie Main
Washington State University, Pullman, WA, USA

Advances in sequencing, sensor, drone and computational technology have led to increasing volumes of genotype and phenotype data being collected and tracked by modern breeding programs. To efficiently store, manage and integrate these large private and public research data sets, so breeders can use them efficiently in decision-making, we are developing the Tripal Breeding Information Management System (BIMS). BIMS is available in the rosaceae, citrus, cool season food legume, vaccinium and cotton NRSP10 Databases. It allows breeders to create and manage access to their breeding programs; upload phenotype data from the FieldBook App or Excel templates; upload genotype data; generate input files for the FieldBook App; archive their entire data to their own computers; search and filter by accessions/lines name, trial, location, cross, parent and trait values; and perform basic statistical analysis. BIMS is being developed in collaboration with public plant breeders. In this presentation we highlight current functionalities available in BIMS and demonstrate how it is being used to improve efficiency in a peach breeding program.

2:50 PM – 3:05 PM

Extending the Tripal Breeding Information System to Combine International Data for Global Performance Predictions

Cameron Peace*
Washington State University, Pullman, USA

An asterisk (*) in front of a name indicates the presenting author.
Breathers Toolbox, initially created as part of the RosBREED program, provided a system to manage pedigree, phenotypic, and genotypic data from a breeding program. As breeding programs have begun to use information on large-effect trait loci and genome-wide predictions for selection of parents, seedlings, and advanced selections, the breeders toolbox is being extended into the Tripal platform as Breeding Information Management System (BIMS) to incorporate new types and amounts of genetic data, as well as to allow breeders to manage their own data. Horticultural tree crop breeding programs tend to be locally focused and there has generally been limited evaluation of the suitability of advanced selections across a broad range of target commercial environments. We propose to extend functionality of this publicly funded Tripal BIMS to support the evaluation of environmental stability of germplasm on a global scale, initially for horticultural crops. Our hypothesis is that a particular phenotype of an individual is a sample of its response to the environment to which it has been exposed, and SNP genotyping can track replicated genomic segments across otherwise unconnected germplasm trials. Our vision is that data from different sources can be compiled into an anonymous database that individual users can interact with to input genotype and phenotypic data and output performance predictions across the range of environments in the dataset.

3:05 PM – 3:15 PM

NSRP10—The Next Five Year Plan: Furthering Integration of Big Data, Tools and Analysis Capability to Enable Specialty Crop Research Discovery and Improvement

Doreen Main*
Washington State University, Pullman, WA, USA

Sook Jung
Washington State University, Pullman, WA, USA

Jodi Humann
Washington State University, Pullman, WA, USA

Cameron Peace
Washington State University, Pullman, WA, USA

Ksenija Gasic
Clemson University, Clemson, SC, USA

James McFerson
Washington State University, TFREC, Wenatchee, WA, USA

National Research Support Project 10 (NRSP10, www.nrsp10.org) is a USDA NIFA, US Land Grant Universities, and industry-funded project which provides standardized database and informatics resources for undeserved or specialty crops such as tree fruit, nuts, and berries. It builds on existing database resources developed for Rosaceae (Genome Database for Rosaceae), Citrus (Citrus Genome Database), Vaccinium (Genome Database for Vaccinium), Cool Season Food Legumes (Cool Season Food Legume Genome Database) and Cotton (CottonGen). Developed using Tripal, an open-source, resource-efficient, modular, well-supported platform, these community databases provide centralized access to integrated genomic, genetic and breeding data and analysis tools for 25 crops representing a combined annual production value of over $25 B. We highlight the broader impacts of the current projects and driven by the research community it serves, we highlight plans for the next 5-year project, which focuses on providing tools and analysis capability to manage and utilize big data for both discovery and crop improvement, whilst leveraging funding from multiple sources as we develop solution for sustainability of these research-enabling resources.

*CEU Approved*

Improvement of Seed Technology Practices in Medicinal (Herbs & Spices) Plants and Horticultural Crops

Coordinator: Katherine Warpeha
University of Illinois at Chicago, Chicago, IL, USA

Moderators: Changbin Chen
University of Minnesota, St. Paul, MN, USA

Amir Khoddamzadeh
Florida International University, Miami, FL, USA

Shinsuke Agehara
University of Florida, Wimauma, FL, USA

Objectives: 1) To explore the challenges in producing seed and advancing seed and horticultural technology with plants of medicinal importance. 2) To discuss the future for crops that are considered ‘new’ medicinal plants. 3) To build coalitions and collaboration among medicinal plant researchers and crop researchers.

Description: This workshop will bring together those ASHS members (including students) who are interested in many types of plants and the valuable seeds they produce. We will have discussion on how we can improve on the seed production, seed technology, seed storage, seed production, seed physiology, seed pathology, plant breeding/propagation of herbs, spices, and medicinal plants. We will have some short talks to lead into discussions on seeds and seed quality, to discuss problems, new methods and how they can help promote horticulture of plants with medicinal properties. Rationale Groundwork: In 2016, Gary Stutte published a Chapter in the American Chemical Society’s eBook series about “Controlled Environment Production of Medicinal and Aromatic Plants” to express concern about the fact that Although controlled environments are widely used for medicinal and aromatic plants...
the production of vegetables and ornamental species, there is limited published data on growth, production, and chemistry of medicinal herbs and plants. Due to the increasing demand worldwide, we would like to discuss 1) what technology is required/needed in the opinion of the participants and 2) what are plants of interest to forge more inroads into increasing safe production of medicinal herbs and plants.

4:00 PM – 4:15 PM

Improvement of Propagation Technology of Medicinal Plants and Crops
Katherine Warpeha*
University of Illinois at Chicago, Chicago, IL, USA

The interest in herbs and medicinal plants for health and treatment has grown significantly in the last 20 years. There are a number of root, shrub and annuals that can be difficult to grow or cultivate in a high throughput way, yet are high in demand. We introduce the workshop by doing an overview of current herbs and medicinal plants where supply does not meet demand, and may not be amenable to standard vegetative or breeding techniques. In addition, we will go over seed treatments that may be required for quality seedlings and stand establishment for greater yields of indoor and outdoor horticulture.

4:15 PM – 4:30 PM

Jujube, a Nutritious Fruit and Medicinal Herb for Its Fruit and Seeds
Shengrui Yao*
New Mexico State University Sustainable Agriculture Sciences Center, Alcalde, NM, USA

Jujube (Ziziphus jujuba Mill.), also called Chinese date, was imported into the US beginning in 1908. Its fruit is rich in vitamin C, cyclic adenosine monophosphate (cAMP), fiber, and antioxidants. Both its fruit and seeds together with seeds from wild jujubes (Z. spinosa) are traditional Chinese medicines. Jujubes grow and produce well in the United States, especially the Southwest. At this time, the limited plant supply is a critical issue limiting the jujube industry. Hopefully, tissue cultured plants will solve the plant shortage problem. Jujube cultivars can be classified as fresh eating, drying, multipurpose and ornamentals. We will discuss the jujube cultivar collections in the United States, cultivar classification and recommendations for growers. We will also discuss the jujube research progress, challenges and opportunities of jujube production.

4:30 PM – 4:45 PM

Assessment of Production and Harvest Potential of Urban Grown Ginkgo Biloba for Economic and Environmental Benefit
Changbin Chen*
University of Minnesota, St. Paul, MN, USA

Ginkgo biloba has been used for thousands of years in the oriental countries in medicine and food. For the North America, ginkgo is considered to be one of the best climatically adaptive species. The species is highly resistant to disease, stress and pests. However, female ginkgo trees may be considered undesirable due to the strong odor of the fleshy seed. In some cases mature female ginkgo trees have been removed for this reason alone. Fortunately, there is growing local interest in assessing ginkgo seed as a valuable new crop. The worldwide market for ginkgo products is approximately 3 billion dollars annually. The majority of the ginkgo market resides in Asian countries; however, there is considerable demand in the United States which is met by importing ginkgo products from overseas. Currently, there are no locally grown sources of ginkgo available in Minnesota. We work on assessing the potential production, harvest, and processing of urban produced ginkgo seeds for sale to local and regional markets. The outcome of which will generate new income in communities with existing ginkgo trees as well as help in preserving this valuable component of the urban forest. In addition, we report our findings regarding the safe uses of urban produced ginkgo nuts, especially the measurement results of heavy metal and ginkgotoxin levels in the ginkgo nuts collected from different locations in Twin-Cities of Minnesota.

4:45 PM – 5:00 PM

Plant Adaptation to Water Stress and Its Practical Application for Phytochemical Production
Shinsuke Agehara*
University of Florida, Wimauma, FL, USA

Plants respond to abiotic stress by inducing antioxidants as a defense mechanism. Such antioxidants include phytochemicals with health-promoting properties and essential oils with medicinal properties. Crop stress management strategies aim to maximize the production of these beneficial chemical compounds by achieving an optimal balance between crop stress and adaptation. Horticultural crops with high health-promoting and medicinal properties, plant stress responses, and, how crop stress management and production practices can be used to promote antioxidant production will be discussed. Particular emphasis will be on water stress and deficit irrigation strategies.

*CEU Approved*

Microclimate Modification Effects on Fruit Physiology and Production
Coordinator: Stefano Musacchi
Washington State University, Wenatchee, WA, USA
Moderator: Thomas M. Kon
North Carolina State University, Mills River, NC, USA

Objectives: The goal of this workshop is to provide an interactive forum to discuss ongoing projects related to microclimate modification in fruit crops, identify common challenges and future research needs, and foster future collaboration among
As fruit production becomes increasingly technology-driven, one orchard challenge remains a significant challenge—the weather. Every fruit grower has experienced potentially damaging climatic events that are difficult to predict, add production risk, and reduce or eliminate profits. Plastic-covered high tunnels can mitigate weather-related risks associated with spring frost, rain, hail, wind or other adverse conditions. However, tunnels also provide the potential to change (for better or worse) the production climate by altering temperatures, light quality and quantity, pest and beneficial insect populations, and diseases, all of which impact plant growth, fruit development, quality, yield, and marketing windows. Different covering strategies may be utilized in different climates to address the risks, or market opportunities, most critical for each region. This presentation will summarize the high tunnel operational parameters and management strategies that can alter orchard microclimatic conditions, and impact developmental and reproductive physiology during production of tree fruits, berries, and wine grapes.

An asterisk (*) in front of a name indicates the presenting author.

Workshops

**Plastic Film Light-transmitting Characteristics As Related to Berry Crop Production**

*Kathy Demchak*  
Pennsylvania State University, University Park, PA, USA  
Richard P. Marini  
Pennsylvania State University, University, University Park, USA  
Maria Cramer  
Pennstate University, University Park, USA  
Eric Hanson  
Michigan State Uiversity, East Lansing, USA

Plastic films used to cover protective structures such as high tunnels and greenhouses vary in their light-transmitting characteristics. These films are manufactured to transmit a high proportion (often 90% or greater) of visible light (and thus PAR), but depending on the film, may block a significant portion of ultraviolet (UV)-A, UV-B, and/or infrared (IR) radiation entering or leaving the structure. Different plastic films also diffuse light to varying degrees, affecting the extent to which light is scattered as it passes through the film. An ongoing multi-state project is testing three commonly used films with a wide range of light-transmitting characteristics, along with two experimental films. Among these commercially available films, transmission of UV-A and UV-B ranges from roughly 5 to 90% depending on plastic film type and wavelength, transmission of visible light ranges from 70 to 95%, and transmission of near IR radiation ranges from 50 to 95%. The experimental films either block nearly all UV, or allow about 80-90% transmission of UV, while allowing transmission of over 90% of wavelengths longer than UV. In an experiment on day-neutral strawberries in single-bay high tunnels in 2016 and 2017, yields with all films were greatly increased compared to no covering, but differences due to film type were minimal, perhaps because plants were at ground level and exposed to similar temperatures when tunnels were vented. With two cultivars of primocane-fruited raspberries in PA in 2017, the first year in which effects were due primarily to plastics rather than previous growth in the nursery, there was an interaction between cultivar and film type. The film that trans-
Protective netting is becoming a widespread technique all around the world. Originally, netting was developed to protect high value perennial crops from hail damage. In some countries the hail risk is covered by insurance. Insurance can protect crop loss but there are other indirect damages that are very difficult to recover. In the case of perennial trees affected by a strong hail storm, not only the current crop can be lost but also the crop of the following year due to the damage of the flower buds. In addition, wounds can become a penetration point for disease like bacteria (Erwinia amylovora fire blight) or fungi. In Europe, netting was developed in the 1970s and there were different shapes of the protective structure. The utilization of netting is associated with the increase of planting density and the modification of the tree canopy related to the use of dwarfing rootstocks. The original structure was initially made of tall posts and a triangular structure to support the net on the top. The use of dwarfing rootstocks, like M9 for apple and Quince for pear, that reduced tree height allowed the structure to become more flat and less expensive by saving on the cost of posts and net. The increasing cost of HDP orchard establishment justify the use of protective netting. Additional advantages of netting are protection against bird, especially in cherry, insect and physiological stress. The Alt-carpo system developed in France in 2005 and validated in 2006 by Severac, is a physical barrier to reduce the damage of Codling moth by the net’s mesh size. This system creates a completely closed net with only one gate to enter and can be applied for large areas or to single row (drop net). All these solutions to cover full orchards or a single row increases benefits for the growers to make production more sustainable. Nets modify physiological conditions of the tree because they induce microclimatic variation. Protective netting primarily modifies light quantity and quality by reducing light intensity by an approximately pre-determined percentage. Protective netting has also been reported to reduce wind speed and soil temperature with minimal impact on canopy temperature, relative humidity and with important effects on fruit quality.

4:20 PM – 4:30 PM

Overview of Netting Systems
Stefano Musacchi*
Washington State University, Wenatchee, WA, USA

Protective netting is becoming a widespread technique all around the world. Originally, netting was developed to protect high value perennial crops from hail damage. In some countries the hail risk is covered by insurance. Insurance can protect crop loss but there are other indirect damages that are very difficult to recover. In the case of perennial trees affected by a strong hail storm, not only the current crop can be lost but also the crop of the following year due to the damage of the flower buds. In addition, wounds can become a penetration point for disease like bacteria (Erwinia amylovora fire blight) or fungi. In Europe, netting was developed in the 1970s and there were different shapes of the protective structure. The utilization of netting is associated with the increase of planting density and the modification of the tree canopy related to the use of dwarfing rootstocks. The original structure was initially made of tall posts and a triangular structure to support the net on the top. The use of dwarfing rootstocks, like M9 for apple and Quince for pear, that reduced tree height allowed the structure to become more flat and less expensive by saving on the cost of posts and net. The increasing cost of HDP orchard establishment justify the use of protective netting. Additional advantages of netting are protection against bird, especially in cherry, insect and physiological stress. The Alt-carpo system developed in France in 2005 and validated in 2006 by Severac, is a physical barrier to reduce the damage of Codling moth by the net’s mesh size. This system creates a completely closed net with only one gate to enter and can be applied for large areas or to single row (drop net). All these solutions to cover full orchards or a single row increases benefits for the growers to make production more sustainable. Nets modify physiological conditions of the tree because they induce microclimatic variation. Protective netting primarily modifies light quantity and quality by reducing light intensity by an approximately pre-determined percentage. Protective netting has also been reported to reduce wind speed and soil temperature with minimal impact on canopy temperature, relative humidity and with important effects on fruit quality.

4:30 PM – 4:40 PM

Light Environmental Manipulation By Colored Nets in Washington State
Sara Serra*
Washington State University, Wenatchee, WA, USA
Stefano Musacchi
Washington State University, Wenatchee, WA, USA

Apple production in Washington State is distributed in five growing regions characterized by a semi-arid climate. However, thanks to the abundance of waters from the Columbia River though the territory this area produces the majority of apples in North America. Crop production in WA is challenged by several environmental factors, such as high light intensity, temperature and wind, that can cause stress to the trees and fruit damage (i.e. sunburn). For those reasons, protective netting is becoming a choice embraced more and more every year by WA growers in order to minimize losses in apple orchards. Originally developed as anti-hail protection, now shading nets can be specifically employed to modify the light spectrum and intensity hitting the orchard canopies by the use of different colors. A commercial orchard of 'CameronSelect® Honeycrisp' on Bud-9 orchard was planted in 2013 in Quincy (WA) and trained to V-system (4485 trees/ha). In Spring 2015 shade pearl, blue and red nets (approx. 20% shade factor) were installed horizontally over the top of the orchard and deployed after bloom. The goal of our trial was to characterize the light intensity and light quality under three different colored nets and compare the modified light environment to the full sun-no net. Spectra of total light and scattered light (diffuse) were measured monthly by a spectroradiometer outside and underneath the colored nets each summer for two consecutive years (2016–17). Transmittance of total light (%) for each colored net and scattered light (%) were measured and light intensity parameters (PAR, UV, Blue, Red, Far Red) were calculated. PAR, UV, Blue, Red, Far Red light in total light measures were always significantly lower under the nets compared to the uncovered controls. The scattered light data showed a higher intensity in the PAR range for the Pearl net compared to the other colored nets in both years. The highest PAR/UV ratio in full light measure was reported under Red nets in 2017. These results confirmed the beneficial effect of Pearl and Red nets for improving light quality in orchards and further studies can address the effects of the modified light on the tree physiology.

4:40 PM – 4:50 PM

Protective Netting Optimization of Light Conditions for Apple Production in Washington State
Giverson Mupambi*
Washington State University, Wenatchee, WA, USA
Lee Kalcsits
Washington State University, Wenatchee, WA, USA

The major apple growing regions in Washington state (WA) are
located in the semi-arid eastern half of the state which experiences harsh environmental conditions due to the rain shadow effect from the Cascade mountain range. Fruit sunburn results in substantial losses to the apple industry every year. To mitigate these losses, the adoption of protective netting to reduce fruit sunburn and tree stress is increasing in WA. The types of protective netting structures commonly used by commercial apple growers in WA are exclusion netting, horizontal over the top of the orchard only and louvered/partial overhead netting. Factors that influence a grower’s decision on the netting structure include cost, amount of protection needed and tree row orientation. The primary benefits of protective netting is the reduction in solar radiation reaching the orchard environment underneath it. Protective netting primarily modifies light quantity and quality underneath by reducing light intensity by an approximately pre-determined percentage. Depending on the cultivar, apple growers in WA use protective netting that reduce the total amount of incoming solar radiation by 10–30% depending on the cultivar. This results in a reduction in photoinhibition and improved photosynthetic light use efficiency. In young orchards under protective netting, trees are able to fill-in the canopy earlier compared to an uncovered control. The reduction in incoming solar radiation under protective netting reduces the occurrence of sunburn by decreasing the amount of radiation reaching the fruit surface and reduces photooxidative damage to the fruit peel. Protective netting has been shown to consistently reduce the incidence of sunburn in apple under high light intensity growing conditions experienced in WA. Overall, protective netting provides is a resilient innovation to protect apple fruit from sunburn and reduce abiotic stress that limits tree establishment in WA.

5:00 PM – 5:30 PM
Panel Discussion

Friday, August 3, 2018
*CEU Approved*

It’s Native. Wait! It’s Exotic . . . Oh No, It’s a Nuisance!

Coordinator/Moderator: Lyn A. Gettys
University of Florida Ft Lauderdale Research and Education Center, Davie, FL, USA

Objectives: The goal of this workshop is to increase attendee awareness and understanding of the phenomenon of invasive native species. Although some may consider the term “invasive native” to be an oxymoron, we argue that some native species can exhibit nuisance-level growth that crowds out other native species, decreases ecosystem diversity and causes problems normally associated exclusively with non-native (introduced) species.

10:30 AM – 10:45 AM
If Waterlettuce Is Native, Why Is It Taking over?
Lyn A. Gettys*
University of Florida Ft Lauderdale Research and Education Center, Davie, FL, USA

Arguments for why we consider Pistia stratiotes to be an exotic species despite its presence in fossil records will be the focus

An asterisk (*) in front of a name indicates the presenting author.
of this lead presentation. This talk will uncover some of the buried history of this invasive species, how it came to be such a problem despite its native status, and why things changed. The speaker will discuss the implications of how such burial of a native’s background can create false impressions in the face of the desperate need for control.

10:45 AM – 11:00 AM

**Other Bad-acting Native Species**
Michael Schnelle*
Oklahoma State University, Stillwater, OK, USA

Natives can evolve and be just as problematic as exotic (non-native) species. They often go unnoticed due to their strategic advantage of being recognizable natives even if they have deleterious effects on humans, landscapes, and local flora and fauna. Natives with subtle but invasive tendencies can affect ecosystem services and sweep through landscapes, often as ornamentals with allied species of economic importance. This talk will focus on but not be limited to the following species capable of escaping cultivation: Black cherry (*Prunus serotina*), Yaupon holly (*Ilex vomitoria*), Inland sea oats (*Chasmanthium latifolium*), and Woodbine (*Clematis virginiana*). This presentation will examine some of the factors leading these indigenous species to invade landscapes and natural areas, and the issues horticulturists and land managers face in light of their presence.

11:00 AM – 11:15 AM

**Challenges of Establishing Native versus Exotic Status of Herbarium Specimens**
Andrzej K. Noyszewski*
University of Minnesota, St Paul, MN, USA

In cases where invasive species are presumed to be strictly exotic, the discovery that the species is also native can be disconcerting for researchers and land managers responsible for eradicating an exotic invasive. Such is the case with reed canarygrass, *Phalaris arundinacea*, where decades of misinformation had led to the call for nationwide control of this species in the US. However, native populations were first reported by LaVoie and then later confirmed by Casler with molecular analyses. This, coupled with the discovery by Anderson that this species has been used in weavings by Native Americans for centuries, also made the native forms of interest for protection. Questions of importance that should be answered when identifying native while controlling exotic/invasive genotypes are the subject of this talk. Identifying the native status of historic, herbarium specimens via molecular analyses is of great interest to determine localities of native populations for confirmation with extant specimens. Historic specimens are often degraded which makes DNA extraction challenging.

11:15 AM – 11:30 AM

**Throwing out the Bathwater but Keeping the Baby**
Neil Anderson*
University of Minnesota, St. Paul, MN, USA

How and why invasive species evolve has long been prejudiced by their labeling and presumed invasive abilities (native = noninvasive; exotic = invasive). Historic ignorance of species’ native range, expansion due to unintentional involvement by vectors, and their quiet evolution has caused several invasive species to become “poster children,” such as purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and others. Common misconceptions on how these became problematic have involved a variety of causes, including sympathy and cross-compatibility creating introgressive hybrids, lack of phytophagous insects for control, wind pollination and intercontinental distribution for their native range. Current research is focusing on how misappropriating the historical contexts can reverse our misconceptions of native species being non-invasive and how this affects control by land managers. *Lythrum* and *Phalaris* will be used as example species to demonstrate challenges that native vs. exotic, intra- and inter-specific differences confer to land managers. Issues such as a lack of phenotypic differences challenge land managers’ charge to control invasive genotypes yet retain noninvasive; this is fraught with challenges when native vs. exotic status is invoked or cultural values are entwined. To avoid a monumental impasse, particularly when native and exotic types are phenotypically indistinguishable, this dilemma could be solved via modern techniques using molecular biology.

*CEU Approved*

**Lessons Learned: A Forum on Communication, Funding, and Student Life By and for Graduate Students**

**Coordinators:** Travis Robert Alexander
Washington State University, NWREC, Mount Vernon, WA, USA

Jack McCoy
University of Arkansas, Fayetteville, Fayetteville, AR, USA

**Moderator:** Kaylee Anne South
The Ohio State University, OARDC, Wooster, OH, USA

**Objectives:** To provide an opportunity for comfortable discussion of major challenges currently facing graduate students, as surveyed this past year, and more importantly, sharing of strategies for overcoming these challenges.

**Description:** Forum on navigating graduate school in the United States as a non-domestic student, balancing funding with real-ized opportunities, and communicating effectively within and beyond science.
Navigating Graduate School As a Non-domestic Student
Shuresh Ghimire*
Washington State University, Mount Vernon, WA, USA

Balancing Funding As a Horticulture Graduate Student
Jack McCoy*
University of Arkansas–Fayetteville, Fayetteville, AR, USA

Communicating within and Beyond Science
Sonja Birthsel*
University of Maine, Orono, ME, USA

*CEU Approved*

Using the GRIN-Global Database As a Research and Breeding Tool
Marty Reisinger*
USDA-ARS, BELTSVILLE, MD, USA

In 1990, the U.S. Congress authorized establishment of a National Genetic Resources Program (NGRP) to: acquire, characterize, preserve, document, and distribute to scientists, germplasm of all lifeforms important for food and agricultural production. The National Plant germplasm System (NPGS) maintains about 600,000 seed samples and distributes almost 250,000 accessions annually to both foreign and domestic researchers. The GRIN-Global Public Website entered into production in 2015 and contains descriptor information on available accessions to aid end users in choosing the best material to order for their breeding and research needs. This workshop is a hands-on tutorial on using GRIN-Global to search and download information on plant genetic resources from the U.S. National Plant Germplasm System.

Cuccap Project Bioinformatic Platforms
Rebecca Grumet*
Michigan State University, East Lansing, MI, USA

A primary objective of the CucCAP project is to develop genomic and bioinformatic platforms for sequence data processing and analysis, and genotype, phenotype and QTL databases for the four major cucurbit crops: watermelon, melon, cucumber and squash. To this end we have performed genotyping by sequencing (GBS) analysis of the full USDA PI collections (1000-2000 accessions) for the four crops, and are using these data to develop sequence-informed functional panels of 300-400 accessions per crop representing ~99% of the genetic diversity along with key disease resistance, horticultural and agronomic traits. Sequence and SNP (single nucleotide polymorphism) data along with maps, markers, population and accession phenotyping data, and gene/trait descriptors can be accessed through the centralized cucurbit genomics database <http://cucurbitgenomics.org/> website.

Coordinated Development of Genetic Tools for Pecan
Jennifer Randall*
New Mexico State University, Las Cruces, NM, USA

The development of a website and integrated databases that will house both pecan genomic data and phenotypic data is one of the deliverables for the USDA NIFA SCRI “Coordinated development of genetic tools for pecan” initiative. The modern U.S. commercial pecan industry developed from the native pecan forest in North America, distributed from Illinois and Iowa south to Oaxaca, Mexico. During the past 30 years, open pollinated
seeds from pecan and other *Carya* species were collected from the wild to represent the native region and planted at two USDA sites. These collections have been characterized for a number of phenotypic traits including inception and duration of growth, disease resistance, nutrient uptake and leaf morphology, and nut quality. Both collections represent the diverse native population with different phenotypic and genotypic characteristics that are invaluable to the industry, making these repositories a national treasure for one of America’s most important tree species. An ArcGIS geodatabase supported by BG-base is being implemented that houses the historic origination records and phenotypic data that represent collections of NCGR *Carya* and this database will connect to GRIN Global. The centralized pecan toolbox will allow for accessibility to the phenotypic and genomic data being generated for the pecan and other *Carya* accessions in the repository. The genomic data includes high resolution genome sequences, genome wide association studies, and RNA-Seq data. We will discuss the formation and implementation of the pecan toolbox that will become an industry-owned website.

*CEU Approved*

**An Overview of High Tunnel Production in the United States**

*Coordinator/Moderator: Lewis Jett*
West Virginia University, Morgantown, WV, USA

**Objectives:** The objective of this workshop is to provide an overview of high tunnel specialty crop production across diverse geographical regions of the United States. The workshop will identify production problems and opportunities that are common among high tunnel specialty crop producers. Given that ASHS will be in Washington, D.C., this gives us a unique opportunity to invite USDA policy personnel who are involved in the Seasonal High Tunnel Program to the workshop. The information presented in the workshop will be an update for commercial horticulturists and USDA personnel. The workshop will include and opportunity for discussion at the end of the presentations and will be a forum for establishing collaborative research and outreach projects.

**Description:** The objectives of this workshop are to present an overview of high tunnel specialty crop production and identify areas which require further research and education. High tunnels are a dynamic season extension technology that is being rapidly adopted by specialty crop growers across the United States. The USDA-NRCS Season Extension Program has facilitated high tunnel production across the United States. However, there is a need to identify and solve problems which may be limiting the maximum productivity and efficiency of high tunnels in the U.S. In addition to problem solving by extension professionals, there is a need for extension horticulturists to successfully connect with high tunnel producers. This workshop will attempt to identify specific areas of high tunnel integrated crop production which require focus from extension and research horticulturists. Successful outreach models for training new high tunnel producers will be discussed. Each presenter in this workshop will pose and answer specific questions related to high tunnel production in their region of the United States. The moderator will channel the expertise and feedback of the audience to address each topic or question. Specific questions which will engage the workshop audience include:

- What is the relationship between Extension and NRCS in individual states with respect to training new high tunnel producers?
- What are some successful outreach methods for training high tunnel producers?
- Are high tunnel specialty crop producers organized into grower organizations?
- Please identify the production issues which may be limiting the efficiency of high tunnels in your region.
- Are high tunnels being used for resource conservation (nutrient, water, soil)?
- How have irrigation and nutrient management recommendations been made to high tunnel producers?
- What are the dominant crop choices for high tunnels in each region and how do growers select crops?
- What are publication and training gaps for high tunnel producers in each region?
- What are some emerging technologies being used for high tunnel crop production in each region (lighting, heating, etc.)?
- How have high tunnel designs been modified for the climate in each region?

1:45 PM – 2:00 PM

**High Tunnels in the Northwest**

*Carol Miles*
Washington State University, NWREC, Mount Vernon, WA, USA

*Heather Stoven*
Oregon State University, McMinnville, OR, USA

*Rob Brown*
Flattop Farm, Anchorage, AK, USA

The use of high tunnels has been somewhat slow to become established in Washington and Idaho, whereas in Oregon high tunnels have been used for several decades in the nursery industry. Direct market farms in the urban periphery in the region use high tunnels predominantly for tomato in the summer and salad greens in the winter. Our research showed that late blight (caused by *Phytophthora infestans*), the disease most limiting tomato production in the region, could be controlled by growing tomato in high tunnels with appropriate management conditions (e.g., good ventilation, not overly high relative humidity). Temperature throughout the winter in western Washington and Oregon tends to be relatively mild, and cold-tolerant crops can be grown in high tunnels with minimal additional protection. In contrast, most of Alaska has very cold winter temperatures, high winds and high snowfall; about $4$ mil. has been awarded by NRCS for high tunnels in Alaska. High tunnels in Alaska...
must be constructed with additional structural support to withstand winter weather.

2:00 PM – 2:15 PM

High Tunnel Production in the Mid-Atlantic
Lewis Jett*
West Virginia University, Morgantown, WV, USA

High tunnels have been widely adopted across the Mid-Atlantic region of the United States. West Virginia has over 500 high tunnels in production. Many of these structures have been funded through the USDA-NRCS. In the Appalachian region, growers are successfully using high tunnels to mitigate the effects of climate change. In addition, four-season cropping plans have been implemented to support local food systems. Research with high tunnels in the Mid-Atlantic has revealed that temperature and nutrient management are areas which require future research. This presentation will summarize cropping systems, designs and management systems used by high tunnel specialty crop producers in the Mid-Atlantic region.

2:15 PM – 2:30 PM

High Tunnel Production in the Deep South
Bill Evans*
Up In Farms Food Hub, Jackson, MS, USA

Lewis Jett
West Virginia University, Morgantown, WV, USA

In 2006, there were very few high tunnels in the southeastern United States. Since that time, hundreds of acres of tunnels have been set in the region bringing production, income and opportunity to large and small farmers. Every state in the south now has high tunnels, with Florida recently reporting 186 acres of installed tunnels. Nearly every land grant institution has installed tunnels to support research, teaching and extension programing now. University research completed or underway include cultivar trials, crop timing, budgeting, organic production, cover crops. With exceptions like Florida’s growing blueberry tunnel production, most high tunnels in the southeast are installed on smaller farms, with hundreds of single bay ranges scatted across each state. USDA-NRCS offices throughout the south have provided funding to support many of these smaller installations. These have also served as capacity building vehicles for small and limited-resource farms. Tunnels are being used to raise organic and non-organic vegetables, herbs, cut flowers and fruit. Grower training and success continues to build with partnerships between grower groups, non-government agencies, state agriculture departments and universities.

2:30 PM – 2:45 PM

High Tunnel Production in the Intermountain West
Karen Panter*
University of Wyoming, Laramie, WY, USA

To paraphrase: Go west young horticulturists! In this pictorial expedition through the western United States, we will discover ways high tunnels are used from the Rocky Mountain states west. The range of uses varies from season extension in the Rockies to crop production in the Pacific Northwest. High tunnels are very much a part of the western horticulture landscape. On our journey we will explore many different construction styles such as roll-up sides, roll-down sides, PVC frames, galvanized steel frames, double poly covers, and fabric covers. A myriad of different crops grown within high tunnels in the west will be highlighted, ranging from aster cut flowers to zucchini fruits.

2:45 PM – 3:00 PM

High Tunnel Production in New England
R. Sideman*
University of New Hampshire, Durham, NH, USA

In New England, the numbers of high tunnels in use, and acreage covered by high tunnels, has increase dramatically over the last decade. In New Hampshire alone, an estimated 10 hectares of new high tunnels have been installed during this time period, spurred in part by the U.S. Department of Agriculture Natural Resource Conservation Service high tunnel program. Season extension structures used in New England are highly customized, sometimes incorporating one or more advanced technologies (automatic ventilation, supplemental heating, in-ground heating, etc.) in various combinations. While high tunnels lack permanent foundations and sophisticated environmental controls, the distinction between greenhouse and high tunnel is not always clear. High tunnels are most commonly used to extend the growing season and increase crop quality for warm-season crops such as tomato, pepper and eggplant, but they are also often used year-round in the northeastern United States. For example, fall-planning of cold-tolerant vegetable crops in unheated high tunnels for harvest and sales throughout the fall and winter months is increasingly common. We will present a regional overview of the most common high tunnel structures and production systems, with an eye toward identifying region-specific and more broadly applicable needs for research and outreach.

*CEU Approved*

Opportunities and Challenges for Transgenic and Gene Editing Approaches to Vegetable and Fruit Breeding

Coordinator/Moderator: Carlos A. Avila
Texas A&M AgriLife Research, Weslaco, TX, USA

Objectives: 1) Explore several examples of how transgenic and gene-editing technologies are being used for crop improvement. 2) Discussions of how these tools are currently perceived by the general public. Increasing genetic variation beyond natural variation is an important aim in plant breeding. New genetic engineering emerging technologies offer the possibility to im-
prove plant resistance and tolerance to biotic and abiotic stresses, agronomic fitness, and produce/fruit quality. Current work on these technologies is mostly performed at the fundamental level, however we need to incorporate these technologies into cultivar development pipelines. The workshop will give an overview of current technologies, opportunities, challenges, and their application in plant breeding programs.

Description: The goal is formidable: to achieve sustainable food security for the world’s growing population. Crop breeders play an important role in this effort, as new varieties are expected to have: increased yields; improved water and nutrient use efficiencies; durable resistance against a myriad of current, emerging and evolving diseases and pests; improved quality characteristics; and resilience in a changing climate. Success will depend upon multidisciplinary efforts for efficient utilization of molecular and conventional crop improvement resources, including newer tools such as transgenic and gene editing technologies. Rather than a technical session on the new emerging technologies, this workshop will highlight some of the opportunities and challenges to the application of these technologies for crop improvement.

1:45 PM – 2:05 PM

Genes and Genetic Interactions That Modulate Flowering and Yield in Tomato: How Gene Editing Technologies Are Facilitating the Translation of These Fundamental Discoveries to Improve Crop Productivity

Sebastian Soyk*
Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, USA

With the recent widespread deployment of genome editing technology in plants, we have entered an era of great excitement and enormous opportunity for plant breeding. Based on knowledge gained on the power of exploiting CRISPR-Cas9 for improving tomato, I will present what is already possible and will likely become feasible in the coming decade of crop improvement. This includes our work on integrating discoveries in basic plant development with agriculture to customize and optimize major productivity traits, and a powerful approach that we have developed to engineer and fine-tune quantitative trait variation.

2:05 PM – 2:25 PM

Development of HLB-tolerant Citrus: From Gene Discovery to Commercial Deployment

Kranthi Mandadi*
Texas A&M AgriLife Research, Weslaco, USA

In the United States, citrus greening or Huanglongbing (HLB) disease is devastating the citrus industry in Florida and starting to spread in Texas and California. No known HLB resistance exists among the cultivated citrus. There is a dire need to control HLB. In this workshop, I will discuss our ongoing efforts to develop HLB-tolerant citrus utilizing the latest genomics, genetics, and biotechnology tools. Furthermore, through partnerships with the citrus industry we are working toward deregulation and commercial deployment of HLB-tolerant transgenic citrus. Such private-public partnerships are critical to save the 1 million commercial citrus acres and $3 billion in annual losses caused by citrus greening in the United States.

2:25 PM – 2:45 PM

Genetic Engineering Approaches for Cultivar Development: Economic Impact and Policies

Jose Falck-Zepeda*
International Food Policy Research Institute (IFPRI), Washington, D.C., USA

Genetically engineered (GE) crops continue to be a controversial issue. The GE approaches to cultivar development include a broad spectrum of techniques from conventional plant breeding and tissue culture to advanced gene editing approaches such as CRISPR/Cas9. The policy debate of whether New Plant Breeding Techniques (NPBTs) such as gene editing, will be regulated as genetically engineered crops in horticulture and other crops continues and has not been resolved. A number of GE technologies exist in the regulatory and/or the decision making pipeline which will be released commercially in the near future. Within this pipeline, NPBTs offer a number of advantages that make them attractive to the public sector worldwide. However, if regulated as GE crops, they may face the same fate of regulatory uncertainty and may not reach end users. The state of affairs in most developing and some developed countries is that of an increasingly complex policy and regulatory landscape. Thus the need exists for innovative strategies to ensure deployment of valuable technologies that may be released by public, private and multi-sector collaborations in the near future. This presentation will examine policy issues related to private and public sectors R&D and deployment of GE crops including those developed using NPBTs. This presentation will also update the current status of GE crops globally, examine the role that policies and regulations may have over technology choice and the level of investments necessary to generate knowledge and thus reduce uncertainty by the public and private sectors with a focus on NPBTs such as gene editing. The presentation concludes with a tentative overview of the challenges and recommendations to support GE crops’ innovation globally.

An asterisk (*) in front of a name indicates the presenting author.
Growing North Minneapolis is an urban agriculture and youth development summer program sited in the North Minneapolis neighborhood. The program is a university-community partnership between faculty and community organizations including Project Sweetie Pie, Youth Resources, and NoMi Roots. We leverage resources from the City of Minneapolis Step-Up program to recruit, train and employ youth (14–15 years old) who face barriers to employment, particularly youth from low-income families, youth of color, youth from immigrant families, and youth with disabilities. Youth interns are placed in a 10-week long summer program and matched with undergraduate student mentors from the University of Minnesota (UMN) College of Agriculture, Food and Natural Resource Sciences; and community garden stewards from the neighborhood. The student mentors and garden stewards work together to lead youth intern teams and work in multiple urban garden sites located in North Minneapolis, a designated low-resource community in the metro. One of our goals is to develop leadership experience for UMN undergraduate students and improve food and horticultural skills and attitudes among urban youth through garden-based education. Learning is experiential and contextualized in the various community garden sites as well as hands-on activities surrounding food justice, food accessibility, food production systems, horticulture science, aquaponics and composting. The experience was designed to develop interpersonal skills for both youth participants and UMN students including the ability to work in teams, communication skills, learning about oneself and others, and responsibility and leadership. We measured skills, knowledge, and attitude changes of youth that resulted from this experience over summer 2017 through quantitative and qualitative metrics. Quantitative metrics included a pre/post test assessing changes in garden-based and food knowledge and attitudes. Focus group sessions or interviews were held for each cohort. Results show that youth participants showed an increase in positive attitudes toward vegetable consumption, cooking, and confidence in gardening skills after the 10-week program.

1:55 PM – 2:05 PM

Urban Agriculture in Asia

Dilip Nandwani*
Tennessee State University, Nashville, TN, USA

Half of the population of developing countries lives in cities, higher (74%) in developed countries. Recently, urban agriculture has gained increasing attention of world communities for the household security of the urban poor and improved land use between urban and rural. However, increase in land prices and taxes, poor infrastructure, disruption of farming activity, pollutions, are a few problems result of extensive urban growth. In Asia, food availability is becoming critical in cosmopolitan areas where most of the urban growth has occurred. Uneven distribution of incomes, shrinking farmlands, inefficient distribution systems, low yields, and poverty have all contributed food...

An asterisk (*) in front of a name indicates the presenting author.
supply and distribution for urban poor. Few Asian cities have been successful in providing foods, most cities in Asia have not paid attention to their prospective food-production or developed policies. Several Asian countries becoming economically strong and depending on imported foods. Japan, South Korea, Singapore, and Malaysia are few examples, whereas Bangladesh, Pakistan, Indonesia, India, and Thailand still depend on domestic food production supply. Japan provide good lessons to other Asian countries where high economic growth, urbanization and advent of modern citizens are taking place correspondingly. A viable division of urban farming is urban horticulture, which has produced innovative systems like organic farming, organoponics and simplified soilless cultures due to malnutrition, the high cost of urban land and with the need of high water- and fertilizer-use efficiency. This presentation discusses benefits, limitations and factors affecting urban agriculture in selected cities and countries in Asia.

2:05 PM – 2:15 PM

Curriculum Development and Training about
Ornamental Plant Production Practices in
Rural Senegal with Winrock International and
the USAID Farmer-to-Farmer Program

John Griffis*
Florida Gulf Coast University, Ft. Myers, FL, USA

In most highly developed countries, ornamental plants and landscaping are just regular parts of the urban environment. However, in third world countries, this is not the situation outside of the large cities. Landscaping and ornamentals are associated with hotels, public parks, government buildings and wealth, not the average individual. However, as urban areas in these countries such as Senegal expand and modernize, there is an increased demand for ornamental plants. An increased opportunity also exists for new jobs and sources of income for individuals who are properly trained in ornamental plant production and maintenance. Senegal has several rural training centers where some courses in agronomy and vegetable production are already taught, but ornamental plants are not included in the curriculum. This Farmer-to-Farmer project was conducted at one of those rural training centers both to introduce this topic into the curriculum and to make the students aware of ornamental plant production practices and the opportunities available to them if they chose to become involved in this “new” business.

2:15 PM – 2:25 PM

Universities As “Engines” of Urban
Horticulture, a Success Story from Virginia

Donielle Nolan*
George Mason University, Fairfax, VA, USA

A special program at George Mason University helps students (and interested community members) to learn how to grow their own food in- and outdoors using hydroponics, worm composting and permaculture techniques. This on campus program supports hundreds of students every semester to earn class credit and gain leadership skills. One of the dining halls on campus serves the salad greens and tomatoes grown in the hydroponic greenhouse. Another approach of the Office of Sustainability at George Mason University is the permaculture design method that relies on perennial plants, like fruit trees and herbs, to grow food with less maintenance. It is practiced on the student campus. Community members can volunteer on campus to receive hands-on training to learn how to grow food sustainably, from seed to harvest.

2:25 PM – 2:34 PM

Chinampas: An Urban Farming Model of the
Aztecs and a Solution for the Megalopolis of
Our Times

Roland Ebel*
Autonomous University of the State of Mexico, Toluca, Mexico

Urban horticulture is not as new as many people think. A chinampa is a garden built as a small, artificial island on a freshwater lake surrounded by canals and ditches. Chinampas were first developed in Aztecs times and still can be found in the region of Xochimilco (close to Mexico City). They are built of aquatic vegetation and mud. The lake delivers water and fertile organic wastes; and fences made of native willow species protect a chinampa from wind and pests, apart from preventing erosion. Main crops are maize, amaranth, legumes, squash, tomato, chili pepper, diverse spice plants, and ornamentals. Complex rotations and associations between these crops allow up to seven harvests per year. Today, chinampas are still producing, but serve primarily as tourist attraction. Recently, diverse research and community initiatives are trying to recover the productive potential of chinampas and align this sustainable and productive system with the achievements and the needs of the 21st century. The chinampa model could help to supply food for big cities, even benefiting from waste water rich in organic matter.

2:34 PM – 2:42 PM

Ancient Urban and Botanicals Gardens of
Persia

Esmaeil Fallahi*
University of Idaho Parma Research & Extension Center, Parma, ID, USA

Pontia Fallahi
Montgomery, Montgomery, AL, USA

Morteza Khosh-Khui
University of Shiraz, College of Agriculture, Shiraz, Iran (Islamic Republic of)

The history of Persian gardens goes back to a few millennia before the emergence of Islam in Iran (Persia). Designs of Persian or Iranian gardens have influenced the designs of gardens all around the globe. Styles of Persian gardens are used extensively in the gardens of Al-Andalus in Spain and Humayun’s Tomb and Taj Mahal in India, and many gardens in the United States and other countries. Bagh in the Persian language (Farsi) means “garden.” For example, it is believed that the word Baghdad (the
capital city of Iraq) is rooted from the words “Bagh” and “Daad" (meaning the garden of justice), since the ancient Persian city of Ctesiphon and supreme court of Ivan-e Madein during Sassanid dynasty of Persia were located near Baghdad. Pasargadae, the capital city and tomb location of Cyrus the Great, is the earliest example of Persian botanical garden design known in human civilization as Chahar Bagh or fourfold garden design. “Bagh-e Eram” or “Garden of Eden” or “Eram Garden,” which is one the most amazing botanical gardens in the world, is located in Shiraz, Iran. Bagh-e Eram was established during the Persian Saljugh dynasty era (1037-1193) and is now over 1000 years old. There are numerous other botanical and urban ancient gardens in Iran, including Bagh-e Shazdeh in Mahan, Golestan National Park near the Caspian Sea, Bagh-e Fin in Kashan, Bagh-e El-Goli in Tabriz, and Bagh-e Golshan in Tabas. The design of each Persian garden is influenced by climate, art, culture, poetry, literature, and romance of the country and the region where the garden is located. Additionally, each garden represents a wide range of germplasm of fruit, flowers, herbs, and vegetables. Although countless gardens were destroyed in the hands of invaders over centuries, Persians have attempted to either rebuild or build new gardens generation after generation, each of which has become a favorite destination for tourists from all around the world.

2:42 PM – 2:50 PM

Challenges and Success of the USAID Farmer-to-Farmer Program, the Example of Central Asia

Ross Penhallegon*
Oregon State University, Eugene, OR, USA

Teaching orchard management in Central Asia is a challenging mission. Gardeners are very poor, have no equipment, little access to agrochemicals, and lack orchard management skills. Since 2005, the goal of USAID farmer-to-farmer volunteers in Tajikistan and Kyrgyzstan has been to teach orcharding skills to horticulturists, emphasizing in pruning techniques, a simple and low-priced way to double their income in two years. The “pruner project” was developed among local Master Gardeners and Oregon farmers. In Lake Issyk-kul, Kyrgyzstan, 75% of the trees are now pruned. And since 2012, 65% of the Tajik trees are pruned as well. One of many success stories: Near the Caspian Sea, Bagh-e Fin in Kashan, Bagh-e El-Goli in Tabriz, and Bagh-e Golshan in Tabas. The design of each Persian garden is influenced by climate, art, culture, poetry, literature, and romance of the country and the region where the garden is located. Additionally, each garden represents a wide range of germplasm of fruit, flowers, herbs, and vegetables. Although countless gardens were destroyed in the hands of invaders over centuries, Persians have attempted to either rebuild or build new gardens generation after generation, each of which has become a favorite destination for tourists from all around the world.

2:50 PM – 3:15 PM

Panel Discussion and Audience Participation

Dilip Nandwani*
Tennessee State University, Nashville, TN, USA

Roland Ebel*
Autonomous University of the State of Mexico, Toluca, Mexico

John Griffis
Florida Gulf Coast University, Ft. Myers, FL, USA

Mary Rogers
University of Minnesota, St. Paul, MN, USA

Amy Bachman
D.C. Central Kitchen, Washington DC, USA

Donielle Nolan
George Mason University, Fairfax, VA, USA

Esmaeil Fallahi
University of Idaho Parma Research & Extension Center, Parma, ID, USA

Ross Penhallegon
Oregon State University, Eugene, OR, USA

The final discussion gives the audience the opportunity to interact with all presenters of this workshop. The nature of successful urban farming projects will be discussed by means of a specific question regarding each presentation:

- Growing North: Connecting Youth and Community through Garden-based Experiential Learning in North Minneapolis—What horticultural and interpersonal development skills can be gained by a summer immersion program for youth in urban agriculture?
- Urban Agriculture in Asia—Several countries in Asia improved food supply in urban areas and many others are struggling. What could be the factors of success and failures in urban development as food supply in Asia?
- Curriculum Development and Training about Ornamental Plant Production Practices in Rural Senegal with Winrock International and the USAID Farmer-to-Farmer Program—Is ornamental production a growth market within urban farming?
- D.C. Central Kitchen: The Pioneers from the Washington D.C. Area—How would you assess the relationship between the success of locally grown food and changing food consumption habits?
- Universities As “Engines” of Urban Horticulture, a Success Story from Virginia—What does it require for a small campus initiative to “spread” to an urban region?
- Chinampas: An Urban Farming Model of the Aztecs and a Solution for the Megalopolis of Our Times—Today, urban horticulture is restricted to niches in big cities. Could production systems like chinampas help to increase its scope?
- Ancient Urban and Botanicals Gardens of Persia—How can the designs of ancient Persian Gardens with their multiple purposes be adopted and be fulfilling for the needs of today’s modern gardens?
- Challenges and Success of the USAID Farmer-to-Farmer Program, the Example of Central Asia—In countries like Tajikistan, are there any differences between farmer-to-farmer missions in rural and in urban regions?
Tactics for Success in the Specialty Crop Research Initiative

Coordinator: Thomas Bewick
USDA-NIFA, Washington, D.C., USA

Objectives: A growing proportion of research funding for horticulture is coming from the Specialty Crop Research Initiative (SCRI) and similar funding programs. The competition for this funding is intense. Nevertheless, successful proposals come from many types of institutions and investigate diverse aspects of horticulture. This session will be helpful to anyone contemplating applying (or reapplying) for SCRI funding, and understanding some of the distinctive characteristics that set this program apart from traditional grants programs.

How SCRI Is Distinctive, the Current Approach to Stakeholder Relevance Review, and the Growing Future Opportunity

Thomas Bewick*
USDA-NIFA, Washington, D.C., USA

8:15 AM – 8:30 AM

How to Read the Request for Applications Accurately

Megan O’Reilly*
Institute of Food Production and Sustainability, N/A, USA

8:30 AM – 8:45 AM

Panel Manager Perspectives

Thomas Bewick*
USDA-NIFA, Washington, D.C., USA
James McFerson
Washington State University, TFREC, Wenatchee, WA, USA
Dewayne Ingram
University of Kentucky, Lexington, KY, USA
Sarah White
Clemson University, Clemson, SC, USA

Panel managers understand the nuances and dynamics of panel function, and what builds consensus in favor of supporting a particular application

8:45 AM – 9:00 AM

Successful Applicants

Thomas Bewick*
USDA-NIFA, Washington, D.C., USA
Ryan Warner

There are diverse models for a successful project. Building support, doing good science, and delivering outcomes that make a difference to stakeholders are all common features. Successful applicants have found distinctive ways to develop those features.

Update on the Cannabis Industry in Canada

Objectives: Jeff Norrie with Breathing Green Solutions will discuss what happening in the growth, production and regulation of cannabis in Canada. Find out how this differs from what is happening in the United States.

Introduction to Pi Alpha Xi

Coordinator: Cindy Slone
ASHS, Alexandria, VA, USA

Objectives: Find out more about Pi Alpha Xi, the National Honor Society of Horticulture. Is there a chapter at your university? How do you become a member? What do chapters do during the year? How do you open a new chapter? The Pi Alpha Xi Board Members will be answering these questions and sharing some history of this great honor society.

Speed Dating—Industry Careers Explained by Industry Scientists

Coordinator/Moderator: Peter Petracek
Valent BioSciences Corp, Libertyville, IL, USA

Objectives: Graduate Students and Young Scientists are invited to this participatory session with Industry Representatives. The presentations will cover the paths to different industry careers and working within the field of science differs in Industry. The session will consist of one hour of talks followed by a reception where students can network with Industry members.

Speakers: Peter Petracek (Valent BioSciences LLC) will present on how to improve your chances of getting an industry job. Jeff Norrie (Breathing Green Solutions) will discuss his switch of industry positions. Steve McArtney (Valent BioSciences LLC) will discuss his move from academia to industry. The presentations will be followed by a free reception for graduate students and postdocs sponsored by Industry.
Thursday, August 2, 2018

Work in Extension

Coordinator: Cindy Slone
ASHS, Alexandria, VA, USA

Objectives: Learn more about the opportunities in Extension.

NIFA Grants—Strategies for Successful Applications

Coordinators: Mathieu Ngouajio
USDA-NIFA, Washington, D.C., USA
Steve Smith
USDA-NIFA, Washington, D.C., USA
Vanessa Lester
USDA-NIFA, Washington, D.C., USA

Moderators: Mathieu Ngouajio
USDA-NIFA, Washington, D.C., USA
Steve Smith
USDA-NIFA, Washington, D.C., USA

Objectives: The purpose of the Meeting is to provide an update of OREI (Organic Agriculture Research and Extension Initiative) and ORG (Organic Transitions) programs; discuss new opportunities with the 2018 Farm Bill, share output and outcome from previous awards; and discuss strategies for successful applications; and receive input on program improvement. The OREI and ORG programs are the flagship programs within the National Institute of Food and Agriculture (NIFA) that support organic agriculture research, education and extension in the United States. Grants are awarded on a competitive basis. We will discuss updates on the programs and strategies for successful applications. The format will be I) full presentations of successful projects, II) short flash talk presentations coupled, and III) open discussion. Additional information on OREI and ORG is available at: <https://nifa.usda.gov/program/organic-agriculture-program>.

10:15 AM – 10:20 AM

Opening and Welcome By NIFA Leadership

Jeff Steiner*
USDA-NIFA, Washington, D.C., USA

10:20 AM – 10:35 AM

Keys to Success for Large Multi-regional Grants: Lessons from the Systems-based Organic Management for Spotted Wing Drosophila Project

Ashfaq Ahmad*
University of Georgia, Athens, GA, USA

10:35 AM – 10:50 AM

Keys to Success for Large Multi-regional Grants: Building a National Coalition to Deliver Regionally Adapted Cover Crop Varieties to Organic Farmers

Steven Mirsky*
USDA-ARS, N/A, USA

10:50 AM – 11:05 AM

Keys to Success for Large Multi-regional Grants: Organization, Goals and Successes of the Northern Organic Vegetable Improvement Collaborative (NOVIC)

James R. Myers*
Oregon State University, Corvallis, OR, USA

11:05 AM – 11:10 AM

Evaluating the Effect of Muskmelon Cultivar and Cover Crops on Soil Biodiversity, and Plant and Human Disease Suppression during Organic Production

Shirley A. Micallef*
University of Maryland, College Park, MD, USA

11:10 AM – 11:15 AM

Blasting the Competition Away: Air-propelled Abrasive Grits for Intra-row Weed Management in Organic Grain and Vegetable Crops

Sam E. Wortman*
University of Nebraska–Lincoln, Lincoln, NE, USA

11:15 AM – 11:20 AM

Research and Extension to Remove Barriers That Limit Transition from Conventional to Organic Maple Syrup Production

Abby van den Berg*
University of Vermont & State Agricultural College, Burlington, VT, USA

11:20 AM – 11:25 AM

A Natural Approach to Human-Pathogen Suppression: Can Biodiversity Fill the GAPs?

William Snyder*
Washington State University, Pullman, WA, USA

11:25 AM – 11:30 AM

Compost Carryover and Cover Crop Effects on Soil Quality, Profitability, and Cultivar Selection in Organic Dryland Wheat

Ian Burke*
Washington State University, Pullman, WA, USA

An asterisk (*) in front of a name indicates the presenting author.
Special Sessions

11:30 AM – 11:35 AM

Strategies to Enhance De Novo Biosynthesis of Methionine for Organic Poultry
Samuel Aggrey*
University of Georgia, Athens, GA, USA

11:35 AM – 11:40 AM

Sustainable Organic Strawberry (SOS) Cropping Systems for the Southeast
Sanjun Gu*
North Carolina Agricultural and Technical State University, Greensboro, NC, USA

11:40 AM – 11:45 AM

Sustainable and Profitable Strategies for Integrated Pest Management in Southern Organic Rice
Xin-Gen (Shane) Zhou*
TAMU, N/A, TX, USA

11:45 AM – 11:50 AM

Evaluation of Paper Bags for Pest and Disease Management in Organic Peach Production
Juan Carlos Melgar*
Clemson University, Clemson, SC, USA

11:50 AM – 12:00 PM

Question & Answer

12:00 PM – 12:15 PM

Lessons from 2018 Panels and Inputs for Future Programs

New Innovations in Horticulture Technologies and Products

Objectives: ASHS Exhibitors presentations on new technologies and/or products.

2:00 PM – 2:20 PM

The Internet of Things Arrives in Horticulture: Utilizing Advancements Both Online and In-the-field to Bring Vital Harvest Data to Your Fingertips Today
Dennis Fisher*
CID Bio-Science, Camas, WA USA

2:20 PM – 2:40 PM

The LI-6800: Advancements in Gas Exchange and Fluorescence Measurements
Elizabeth Gordon*
Li-COR, Lincoln, NE, USA

2:40 PM – 3:00 PM

NDVI, Red-Far Red, and PRI Sensors from Apogee Instruments
Schuyler Smith*
Apogee Instruments, Logan, UT, USA

3:00 PM – 3:20 PM

Passion for Partnership
Mike Marett*
Rimol Greenhouse Systems, Inc., Hooksett, NH, USA

3:20 PM – 3:40 PM

Future Farming: Substrate, Robotics, and Analytics in Berry Production
Logan McCollum*
Driscoll’s, Watsonville, CA, USA

3:40 PM – 3:55 PM

Monitoring Plant Water Relations
Alec Downey*
ICT International, Armidale, Australia

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**Part 2: Oral Presentations**

**Tuesday, July 31, 2018**

### Genetics and Germplasm 1

**Moderator:** Gayle M. Volk  
USDA-ARS National Laboratory for Genetic Resources Preservation,  
Fort Collins, CO, USA

**8:15 AM – 8:30 AM**

**Outcomes of an International Workshop to Develop Training/Educational Programs for Plant Genetic Resources Management**

Gayle Volk*  
USDA-ARS National Laboratory for Genetic Resources Preservation,  
Fort Collins, CO, USA

Patrick Byrne  
Colorado State University, Fort Collins, CO, USA

Peter Bretting  
USDA ARS ONP GW Carver Ctr Mailstop 5139, Beltsville, MD, USA

There is an urgent need to develop foundational training for Plant Genetic Resources Management at a national level. A workshop was convened in Apr. 2018 to identify the necessary scientific backgrounds, practical genebank management skills, and potential training/education formats to address this need. Workshop participants included representatives from the USDA-ARS National Plant Germplasm System (NPGS), USDA/NIFA, land-grant universities, industry, international genebanking programs, and a botanic garden. They represented NPGS curation and management teams as well as those who utilize genebank materials in their research and breeding programs. Together, these participants identified a combination of potential mechanisms for graduate students, genebank staff, as well as members of the international community, to be trained in core aspects of plant genebanking. The workshop identified a plan for developing and delivering a Plant Genetic Resource Management training/educational program in the near future. This presentation summarizes the outcomes of the workshop and seeks feedback from the horticulture community about the proposed training/educational program.

**Specified Source(s) of Funding:** NIFA

**8:30 AM – 8:45 AM**

**The Challenges of Polyploid Crop Breeding: Survey Results**

David Byrne*  
Texas A&M University, College Station, TX, USA

A survey developed within the Tools for Polyploid SCRI planning grant collected information on the range of polyploid specialty crops to determine their characteristics and breeding needs. One-hundred and three responses including 36 root/tuber, 25 ornamental, 32 fruit and 10 turf breeding programs were received. The major crops represented were potato, sweetpotato, rose, blueberry, strawberry, kiwi, *Rubus*, bluegrass, and ryegrass. The majority of the polyploid specialty crops were clonally propagated and highly heterozygous with genetic backgrounds that include either interspecific and interploidy hybridization. Although the type of ploidy is not always known, the crops ranged from auto to allopolyploids with many segmental allopolyploids. These crops showed disomic to tetrasomic to mixosomic segregation depending on the crop and genetic background within a crop. Although the most common ploidy level was tetraploid, there were significant numbers of crops that were triploid, hexaploid and octoploid. The programs ranged in size from less than 3000 to more than 100,000 seedling per year and most commonly used backcrossing, recurrent selection and interspecific hybridization breeding approaches. The major impediments encountered when trying to incorporate genomic tools in their breeding were software tools to analyze polyploids, analytical expertise and more efficient phenotyping tools. On average, the polyploid breeders had medium to high confidence that they would be able to incorporate genomic tools to accelerate their breeding progress within 5–10 years.

**Specified Source(s) of Funding:** NIFA, SCRI grant “Tools for Polyploids”, #2017-51181-26824

**8:45 AM – 9:00 AM**

**Determining Chloroplast Haplotype Variation of Wild American Hazelnut**

Alex Mayberry*  
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Josh Honig  
Rutgers University, New Brunswick, NJ, USA

John Michael Capik  
Rutgers University, New Brunswick, NJ, USA

Jennifer Vaiciunas  
Rutgers University, New Brunswick, NJ, USA

Christine Kubik  
Rutgers University, New Brunswick, NJ, USA

Thomas Molnar  
Rutgers University, New Brunswick, NJ, USA

*Corylus americana*, the American hazelnut, is native to a wide area of land in eastern North America. It is resistant to the disease eastern filbert blight (EFB) caused by the fungus *Anisogramma anomala*, and is cross-compatible to the EFB-susceptible cultivated European hazelnut, *Corylus avellana*. Rutgers University has amassed a diverse collection of wild American hazelnuts, comprising 1900 seedlings from 126 individual seed lots spanning 23 states and one Canadian province. In this study, variation of chloroplast haplotypes in a large subset of the collection were determined in an effort to better understand population structure and associated evolutionary and post-glacial migration history of the native hazelnut. In total, 379 individuals from 23 states were included and compared to 20 reference accessions of European hazelnut that span a significant subset of known genetic diversity in *Corylus*. Sequences from eight different regions of the chloroplast were examined, consisting
The main objectives of this study are to identify fruit-elongation rates during fruit development and BER occurrence. Currently we have identified 29 EXP genes in bell pepper using database resources available from NCBI GenBank and the Sol genomics network. To determine the expression of EXP, bell pepper cultivar ‘Aristotle’ was grown under greenhouse conditions. Samples were harvested from seedlings, leaves, flowers and fruit at various days after anthesis (DAA; 7DAA, 14DAA, 21DAA, 28 DAA) including ripening. Gene expression is being performed using quantitative RT-PCR analysis. Fruit samples from the above stages are being analyzed for cell elongation rates using microscopy. In addition calcium accumulation during fruit growth phase will be determined. The expression of EXP and its role in cell expansion and calcium accumulation rates will be compared using BER resistant and susceptible bell pepper varieties. Collectively, this study will help to determine the importance of EXP in cell expansion and development of BER in peppers.

9:00 AM – 9:15 AM

**Expansins and Its Role in Cell Elongation during Blossom-end Rot Development in Bell Pepper**

Andres Mayorga-Gomez*
University of Georgia, Athens, GA, USA

Savithri U. Nambeesan
University of Georgia, Athens, GA, USA

Juan Carlos Díaz-Pérez
University of Georgia, Athens, GA, USA

Timothy Coolong
The University of Georgia, Tifton, GA, USA

Blossom-end rot (BER) is a common physiological disorder in peppers that occurs during early stages of rapid fruit growth. It is characterized by a dry, sunken, brown rot to the distal part of fruit resulting in huge economic losses. Occurrence of BER has been related to insufficient calcium uptake during the cell expansion phase of fruit growth leading to cell wall disintegration. **Expansins (EXP)** play an important role in facilitating cell expansion by loosening the cell wall in response to cell internal turgor. The main objectives of this study are to identify fruit-specific EXP during cell expansion phase and to determine cell elongation rates during fruit development and BER occurrence. Currently we have identified 29 EXP genes in bell pepper using database resources available from NCBI GenBank and the Sol genomics network. To determine the expression of EXP, bell pepper cultivar ‘Aristotle’ was grown under greenhouse conditions. Samples were harvested from seedlings, leaves, flowers and fruit at various days after anthesis (DAA; 7DAA, 14DAA, 21DAA, 28 DAA) including ripening. Gene expression is being performed using quantitative RT-PCR analysis. Fruit samples from the above stages are being analyzed for cell elongation rates using microscopy. In addition calcium accumulation during fruit growth phase will be determined. The expression of EXP and its role in cell expansion and calcium accumulation rates will be compared using BER resistant and susceptible bell pepper varieties. Collectively, this study will help to determine the importance of EXP in cell expansion and development of BER in peppers.

9:15 AM – 9:30 AM

**Genetic Diversity and Population Structure of a Sweetpotato (*Ipomoea batatas*) Germplasm Collection**

Phillip A. Wadl*
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USDA-ARS, U.S. Vegetable Laboratory, Charleston, SC, USA

Sweetpotato, *Ipomoea batatas*, plays a critical role in food security and is the third most important root crop worldwide following potatoes and cassava. Sweetpotato is an important crop in the United States (U.S.) and is valued at over $700 million dollars annually. The U.S. sweetpotato germplasm collection is maintained by the USDA-ARS, Plant Genetic Resources Conservation Unit. There is currently a lack of knowledge of the genetic diversity within this collection that supports sweetpotato crop improvement. To date, no genome-wide assessment of genetic diversity of this collection has been reported. In our study, population structure and genetic diversity of 417 sweetpotato accessions originating from 8 broad geographical regions (Africa, Australia, Caribbean, Central America, Far East, North America, Pacific Islands, and South America) were genotyped with over 30,000 SNPs using a genotyping-by-sequencing (GBS) protocol optimized for sweetpotato. A neighbor joining cladogram and principal coordinates analysis based on the genetic relationships among the accessions indicated three major groups (North American, South American, and remaining regions). Pairwise FST values between broad geographical regions based on the origin of accessions ranged from 0.017 (Far East–Pacific Islands) to 0.110 (Australia–South America) and supported the clustering of accessions based on genetic distances. The markers developed for use with this collection of accessions provide an important genomic resource for the sweetpotato community, and contribute to our understanding of the genetic diversity present in the U.S. sweetpotato genebank.

9:30 AM – 9:45 AM

**A Chromosome-Level Reference Genome of Wild Diploid Potato Species *Solanum Bulbocastanum***

Kelly Vining
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Iovanna Pandelova
Oregon State University, Corvallis, OR, USA

An asterisk (*) following a name indicates the presenting author.

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Vidyasagar Sathuvalli*
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The wild, diploid (2n = 2x = 24) potato species *Solanum bulbocastanum* harbors disease and pest resistance genes that have been successfully introgressed into tetraploid potato breeding clones. We are developing genome resources for this species in order to study the genetic basis of resistance to Columbia Root Knot Nematode. We improved our Illumina-based draft genome assembly for *S. bulbocastanum* accession SB22 using long read sequencing. Sequencing libraries of 20 kb and 35 kb were run on a total of 44 SMRT cells on a Pacific Biosciences Sequel instrument. The resulting 39 Gb of sequence data were assembled into 1,301 contigs totaling 600 Mb. Chromosome confirmation capture performed by Dovetail Genomics was used to order the assembled genome contigs on twelve pseudochromosomes. A total of 32,943 protein-coding genes were predicted in the genome. This genome sequence is a resource for the study of disease resistance mechanisms in potato, and for development of molecular markers for marker-assisted selection in potato breeding programs.

*Specified Source(s) of Funding:* Northwest Potato Research Consortium

9:45 AM – 10:00 AM

Genomic Resequencing of Bulked Heat-tolerant and Heat-susceptible Broccoli Segregants Identifies New QTLs Associated with Tolerance

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Mark W. Farnham*
USDA-ARS U.S. Vegetable Laboratory, Charleston, SC, USA

Broccoli is an economically important vegetable crop in the United States (U.S.) with an annual farm-gate value approaching a billion dollars. Nearly all commercial cultivars available to U.S. producers were developed for adaptation to relatively cool climates of California and other western states, where about 90% of broccoli production traditionally occurs. Head quality is negatively impacted by high temperatures (e.g., >30 °C) occurring during early stages of head development, and the resulting reduced quality can lead to significant marketable yield losses. There is renewed interest in breeding broccoli cultivars for East Coast production, but this effort is challenged by unpredictable high temperature spikes, higher nighttime temperatures during growing seasons, and limited knowledge of the genetic basis of heat tolerance. A doubled haploid broccoli population segregating for heat tolerance was evaluated in two summer field trials under conditions that readily cause head damage. The most and least tolerant broccoli lines were identified and then screened in two additional summer field trials. A subset of the most extreme tolerant and susceptible phenotypes were separately pooled for bulked segregant analysis using whole genome re-sequencing. Two novel QTLs were identified that did not co-locate with previously characterized heat tolerance QTL.

*Specified Source(s) of Funding:* USDA-ARS and USDA-SCRI

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**Plant Nutrient Management 1**

*Moderator:* Francesco Di Gioia

University of Florida, Gainesville, FL, USA

8:30 AM – 8:45 AM

Distribution and Use Efficiency of Phosphorus in Tomato Grown on a Calcareous Soil

Qiang Zhu*
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Monica Ozores-Hampton
University of Florida, Immokalee, FL, USA

Yuncong Li
University of Florida, homestead, FL, USA

Kelly Morgan
University of Florida, Immokalee, FL, USA

Florida usually ranks first in the fresh-market tomato (*Solanum lycopersicum* L.) production in the United States. However, there are limited studies on phosphorus (P) accumulation and distribution in tomato as affected by P rates in calcareous soils. Thus, the objective of this study was to determine the effects of P rates on P uptake and partitioning, soil P budget, and P use efficiency in tomato production in a calcareous soil. A field trial was conducted during the winter season of 2015 in Homestead, FL. Treatments included six P rates: 0, 29, 49, 78, 98, and 118 kg·ha⁻¹, and they were arranged in a randomized complete-block design with four replications. Dry P fertilizers were used and banded in the bed prior to transplanting. The stems, leaves, roots, and fruits from one plant per plot were collected 95 days after transplanting (DAT) and measured plant dry biomass, P concentration, and P uptake. Soil samples were collected 82 DAT and analyzed for Mehlich-3 extractable P. Leachate were captured by gravitational lysimeters and analyzed for dissolved reactive P (DRP) concentration. Tomato fruits from ten plants per plot were harvested three times at 88, 102, and 116 DAT. Phosphorus apparent recovery efficiency (ARE) and partial factor productivity (PFP) were calculated. Results showed that total P uptakes (TPU) were not significantly affected by P rates and averaged 12 kg·ha⁻¹. The proportions of stem, leaf, root, and fruit in the TPU ranged from 16 to 22%, 40 to 46%, 0.8 to 1.2%, and 32 to 43%, respectively. The ratio of stem/TPU decreased with increasing P rates and reached a plateau at 106 kg·ha⁻¹, but the proportions of leaf, root, and fruit were not significantly affected. Soil P and cumulative leachate DRP increased linearly with increasing P rates. The rate of 49 kg·ha⁻¹ resulted in a higher ARE than 29, 78, and 98 kg·ha⁻¹. Tomato marketable yield at the first and second combined harvest was predicted by a linear-plateau model with a critical rate of 56 kg·ha⁻¹. There were no significant differences in the total season (three harvests combined) marketable yields, thus, the PFP decreased with increasing P rates. Consequently, in the calcareous soils with 51 mg·kg⁻¹ of Mehlich-3 extractable P, 56 kg·ha⁻¹ was sufficient to meet tomato P requirement.

*Specified Source(s) of Funding:* Florida Department of Agriculture and Consumer Services

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An asterisk (*) following a name indicates the presenting author.
Tomato Response to Polyhalite As a Potassium and Secondary Nutrient Source in Southeast Brazil

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Brad Farber*  
Sirius Minerals, Scarborough, United Kingdom

Polyhalite (PH) is a naturally occurring multi-nutrient fertilizer containing 14% K2O (potassium oxide), 17% CaO (calcium oxide), 6% MgO (magnesium oxide), and 19% S (sulfur). We recently reported the positive response of tomato (Solanum lycopersicum L.) to PH, in comparison to muriate of potash, sulfate of potash, and potassium magnesium sulfate (SOPM) from two rate response trials in Sao Paulo, Brazil. However, PH as a sole K (potassium) source exceeds crop S requirement and there is a need to determine its appropriate inclusion rates. The current study evaluated SOP, SOPM, SSP (single super phosphate) and PH as sources, each supplying a 40 kg·ha⁻¹ S at three sites. Uniform K rate was ensured for the above treatments by varying MOP application rates. There were two control treatments, one did not contain K and S (KS control), and the other one contained K but not S (S control). All treatments received constant N (nitrogen) and P (phosphorus) rates. Yield, quality, foliar and fruit nutrient data was collected and analyzed by ANOVA in JMP software. Sources and rates were defined as fixed and random factors, respectively and the blocks were nested in site. Tukeys means separation procedure was used at 10% significant level. Pretrial soil pH was 5.3, and soil K ranged from 61 to 83 mg·kg⁻¹, soil Ca ranged from 250 to 266 mg·kg⁻¹, and soil Mg ranged from 70 to 82 mg·kg⁻¹. Only PH treatment increased total and marketable yields and fruit numbers compared to KS control which could be explained by the multi-nutrient composition of PH. In general, ascorbic acid, titratable acidity, and fruit pH were lower in the KS control compared to all other treatments. Fruits from all treatments were found to be similar for brix and firmness. Foliar K concentration was lower in KS control than all other treatments and foliar P concentration was lower in both KS and S controls than SSP, while both PH and SSP resulted in higher foliar S concentration than KS and S controls. Interestingly, KS control resulted in higher foliar Ca concentration than all other treatments except PH, possibly be due to lower competition between potassium and calcium in KS control and PH treatments. Consistently increased total and marketable yield for PH confirms its usage as a potential multi-nutrient source in Sao Paulo state of Brazil for tomato cultivation.

Specified Source(s) of Funding: Sirius Minerals

Seasonal Changes in Growth Dynamics, Nitrogen Nutrition, and Yield of Hydroponic Lettuce in Response to Nitrogen Fertilization

Daniel Leskovar  
Texas A&M AgriLife Research & Extension Center, Texas A&M University, Uvalde, TX, USA

Desire Djidonou*  
Texas A&M AgriLife Research, Uvalde, TX, USA

Understanding the pattern of growth, nutrient uptake and utilization is a prerequisite to effectively managing fertilization programs in any cropping system including leafy vegetables in hydroponic production systems. An experiment was carried out in an unheated and naturally-lit hoop-house in Uvalde, TX to determine the effect of different concentrations of nitrogen (N) on plant growth. Leaf nitrogen index (LNI), yield, and N use efficiency (NUE) of lettuce grown over three consecutive seasons (fall, winter, and spring) in a recirculating hydroponic system. During each season, three lettuce varieties including Buttercrunch, Dragoon, and Sparx were grown in six N concentrations, i.e., 100, 150, 200, 250, 300, and 400 mg·L⁻¹ using a nutrient solution (100 mg·L⁻¹ N) in an unheated and naturally-lit hoop-house in Uvalde, TX. Averaged over variety and season, N concentrations, accumulated biomass at harvest during the spring season was 73 and 34% greater than those of fall and winter, respectively, mostly due to the highest relative growth rates. At each sampling date, there were linear, quadratic, and cubic effects of N concentrations on each of these variables. Furthermore, the results revealed that Sparx is the most productive variety which exhibited 63 and 32% higher fresh marketable yield than those of ‘Buttercrunch’ and ‘Dragoon’, respectively during the fall season and 145 and 114% in spring. Overall, increasing N concentrations from 100–400 mg·L⁻¹ increased the marketable fresh yield linearily or curvilinearly (quadratic or cubic) from 5.9–6.7 kg·m⁻² in fall, 8.1–10.7 kg·m⁻² in winter, and 10.3–12.6 kg·m⁻² in spring. Additionally, NUE values were highest at the lowest N concentration (100 mg·L⁻¹) and significantly increased in response to increasing N concentrations in the nutrient solution. Similarly, LNI values during mid to late growth stages were near or above 1 even for the lowest N nutrient solution (100 mg·L⁻¹). These results demonstrated that N concentrations of 100 to 150 mg·L⁻¹ can maximize growth and yield of hydroponic grown lettuce.

Specified Source(s) of Funding: Texas Department of Agriculture Specialty Crop Block Grant
Oral Presentations

9:15 AM – 9:30 AM
Interactive Effects of Late-season Nitrogen Management and Foliar Disease on Nitrate Accumulation in Processing Carrots

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Daniel Brainard
Michigan State University, East Lansing, MI, USA

Root nitrate concentration is an increasingly important quality concern for a large segment of the processing carrot industry, most notably where carrots are grown for baby food. Nitrogen (N) fertilizer topdress applications are often made late in the season in part to promote adequate and healthy carrot shoot growth, a key requirement for effective mechanical harvest; however, this may also increase risk of high nitrate content at harvest. Late-season foliar disease severity has the potential to further exacerbate nitrate challenges by reducing shoot N demand. The objective of this research was to investigate how late-season N management strategies and foliar disease influence dynamics of carrot root nitrate accumulation and production tradeoffs. Two on farm experiments were conducted in 2017 on sandy soils in Hart, MI. Carrots (cv. Cupar) were planted in mid-April and harvested in mid-October. Experiment 1 evaluated the effects of late-season (September) N fertilizer rate (0, 34, 67, or 101 kg·ha⁻¹ as urea) and source (urea, slow-release, or foliar applied N) on carrot yield and quality, root nitrate content, and shoot growth. Carrot roots were subsampled every 2 weeks leading up to harvest to evaluate temporal dynamics in root nitrate concentration. In Experiment 2, a subset of three treatments from a larger fungicide spray trial were selected to represent a gradient of foliar disease severity (low, medium, and high), and carrot subsamples were collected at harvest to evaluate impacts on root nitrate. Carrot yield was not affected by late-season N fertilizer rate or source treatments. Similarly, no significant differences in shoot biomass were observed, despite a modest trend toward greater biomass with higher N rates. All September N applications increased root nitrate content relative to the control. For N rates greater than 34 kg·ha⁻¹, nitrate concentrations increased linearly between fertilizer application and harvest. Slow release and foliar applied N both maintained lower root nitrate levels than urea over the course of the experiment. Foliar fungal disease severity was positively correlated with root nitrate at harvest, with concentrations over seven times greater in high disease treatments (50 to 75% leaf area affected, Horsfall-Barratt scale) than in low disease treatments (3 to 6% leaf area affected). Our results suggest that late-season N applications in excess of recommended total season rates may have limited production benefits for carrots harvested in October, while also increasing risks of excessive nitrates, particularly if conditions are favorable for foliar disease.

Specified Source(s) of Funding: USDA/MDARD SCBG

9:30 AM – 9:45 AM
Nutrient Distribution and Uptake Patterns in High Density Citrus Groves on Flatwoods Soils

Davie Kadyampakeni*
University of Florida, Lake Alfred, FL, USA

Kelly Morgan
University of Florida, Immokalee, FL, USA

Citrus production in Florida occupies an estimated 176,848 ha, and had a crop value of $800 million in 2017. The total impact of citrus on Florida’s economy is approximately $8.6 billion a year. The sandy soils, with more than 97% sand content, are prone to leaching of fertilizers and other agricultural chemicals when over-irrigation, heavy storms or hurricanes occur. Good understanding of nutrient movement and uptake in the root zone is critical for proper placement and timing of fertilizer applications. Experiments were conducted to determine nutrient and biomass accumulation patterns in young citrus grown on Florida sandy soils. Results show improved nitrogen uptake by up to 45% using intensive microsprinkler and drip fertigation practices and reduced inorganic nitrogen (N), phosphorus (P), and potassium (K) leaching compared with conventional microsprinkler practices. Biomass, P, and K accumulation among the fertilization practices was comparable over the years of study. The reduction in N leaching and improved uptake is important because it helps growers reduce N losses especially in summer months when leaching is exacerbated by rains.

Specified Source(s) of Funding: SWFWMD/FDACS

9:45 AM – 10:00 AM
Production of Low Potassium Content Microgreens to Enhance the Diet of Patients Affected By Hyperkalemia

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University of Florida, Gainesville, FL, USA

Carlo Mininni
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Francesco Serio
Institute of Sciences of Food Production, National Research Council, Bari, Italy

Giulia Conversa
University of Foggia, Foggia, Italy

Antonio Elia
University of Foggia, Foggia, Italy

Pietro Santamaria
Universita' degli Studi di Bari, Bari, Italy

Defined as an excess of potassium (K) in the blood (≥ 5 mmol·L⁻¹), hyperkalemia is a potentially life-threatening clinical condition while also increasing risks of excessive nitrites, particularly if conditions are favorable for foliar disease.
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Oral Presentations

Affecting an increasing number of people worldwide. Commonly associated with chronic kidney disease (CKD) and other comorbidities (diabetes, cardiovascular disease, and hypertension), hyperkalemia derives from an impaired capacity to excrete K, or maintain its homeostasis between intra- and extra-cellular compartments. Patients affected by hyperkalemia must reduce the daily dietary intake of K limiting the consumption of high-K fruit and vegetables. Thereby, reducing also the intake of vitamins and bioactive compounds normally assured by the consumption of fruit and vegetables. Aiming to improve and enrich the diet of patients affected by hyperkalemia, a study was conducted to investigate the possibility to produce high quality low-K microgreens suitable for raw consumption. Broccoli (Brassica oleracea L. conv. botrytis (L.) Alef. var. cymosa Duch.), rapini (Brassica rapa L., Broccolietto group), and red cabbage (Brassica oleracea L. var. capitata f. rubra DC.) microgreens were grown in a soilless subirrigation system with nutrient solutions (NS) containing 3 (K3), 0.75 (K0.75), or 0 (K0) mM of K. At harvest, 12 days after sowing, yield components, mineral content, total phenols (TP), and total antioxidant activity (TAA) were examined for all three species. The three species responded similarly to reduced K inputs. Potassium content of microgreens of the three species grown with K3 NS ranged between 191 and 255 mg 100 g of fresh product, which may provide between 9.5% and 17.0% of the daily recommended intake of K for people affected by hyperkalemia. Fertilization with K0.75 or K0 decreased microgreens K content by 49 to 59% and 79 to 92%, respectively, which may supply about 2.0% to 8.7% of the daily recommended intake of K. Fertilization with K0.75 had no effects on yield and dry matter (DM) content compared to the standard NS, while fertilization with K0 decreased microgreens yield by 28% and increased DM content by 21%. TP increased with decreasing the level of K in the NS. TAA was on average 35% higher in microgreens grown with reduced level of K compared to those grown at the standard level. In conclusion, reducing the level of K in the NS, it is possible to produce high-quality low-K microgreens suitable to satisfy the dietary needs of patients affected by hyperkalemia, with no or limited microgreens yield decrease.

Specified Source(s) of Funding: Project “Gusta il Biodiverso” Principi Attivi 2012 funded by Apulia Region, Italy

Viticulture and Small Fruits 1

Moderator: Nahla V. Bassil
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8:30 AM – 8:45 AM

Verifying Parentage and Confirming Identity in Blackberry with a Fingerprinting Set

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Parentage and identity confirmation is an important aspect of clonally propagated crops outcrossing. Potential errors resulting misidentification include off-type pollination events, labeling errors, or sports of clones. DNA fingerprinting sets are an excellent solution to quickly identify off-type progeny or confirm clonal identity. A previously developed simple sequence repeat (SSR) fingerprinting set consisting of six primer pairs was used to verify parentage of seedling populations representing important blackberry (Rubus subg. Rubus) accessions from the University of Arkansas (UA) and the USDA-ARS Horticulture Crops Research Unit (HCRU) breeding programs. Six seedling populations from the UA and 12 seedling populations from the USDA-ARS breeding programs were genotyped. Incorrect parentage was detected where alleles that were absent in both parents occurred in seedlings. In the UA breeding program, 16 individuals were off-type while 11 individuals were off-type in the USDA-ARS HCRU program. In one of the USDA-ARS HCRU populations, ORUS 4647, all five individuals were off-type; the male parent was unknown. For parentage confirmation, the 6-SSR fingerprinting set was sufficient, however, 28 groups of individuals had identical DNA fingerprints. To achieve better resolution, 15 SSRs were examined. An improved 8-SSR fingerprinting set was developed by removing one marker from the 6-SSR set and adding three markers that differentiated undifferentiated individuals. The 8-SSR fingerprinting set reduced the number of indistinguishable samples to 10 groups consisting of two progyn per group. Interestingly, these groups consisted of adjacenty planted individuals. Sampling errors may have occurred where the plants were inter-grown. The 8-SSR fingerprinting set was also used to evaluate a set of 71 Rubus clones from the USDA-ARS National Clonal Germplasm Repository (NCGR) to compare accessions that may be identical and to establish a library of genotypes for future identity comparison. The 8-SSR fingerprinting set was applied to ‘Boysen’ subclones, its presumed parents, and additional samples from private growers and commercial nurseries. Multiple subclones of this cultivar have been horticulturally recognized since the genotype was introduced in 1935. The results suggested which clone was most likely to be true-to-type, that ‘Lucretia’ was not a parent of ‘Boysen’, and grouped the ‘Boysen’ subclones into two general categories. Continuing work will focus on establishing pedigree or relational links for blackberry and hybrid berry cultivars.
Influence of Supplementary Foliar Nutrients on Crop Yield and Fruit Quality of Two New Primocane Bearing Blackberry Cultivars
Mikel Conway*
Hampton Roads AREC, Virginia Tech, Virginia Beach, VA, USA
Jayesh Samtani
Hampton Roads AREC, Virginia Tech, Virginia Beach, VA, USA

Supplemental foliar nutrient products are applied by some berry growers to improve sugar content, fruit quality and yield. However, there is not sufficient evidence that these applications improve fruit quality or increase crop yield. Virginia growers have limited information on new thornless, primocane bearing blackberry cultivars—PrimeArk® Freedom and PrimeArk® Traveler. Both primocane cultivars are considered comparable for USDA hardiness zones 4–8. A study was conducted at the Hampton Roads Agricultural Research and Extension Center, Virginia Beach, VA (USDA zone 8A) with thirty-six Prime-Ark® Freedom and PrimeArk® Traveler plants each that were established on raised beds covered white woven polyethylene and supported by T-post trellis. The objective of this study was to determine if supplemental foliar treatments showed increases in total soluble solids (TSS) content, yield and fruit size. Three sources of foliar nutrient treatments were applied using recommended label rates of: AgGrand (4–3–3); Sugar Express (40–10–40); K-Ace (0–0–25). An untreated control that received no supplementary nutrient was included in the study. Six foliar applications treatments were applied (17 Apr., 5 May, 27 May, 11 June, 25 June, and 16 July 2017) at various growth stages from pre-bud to bloom through harvest. There were no significant differences between control and those that received foliar treatments, on crop yield, TSS content, or overall fruit size. The study will be repeated in the 2018 growing season.

Specified Source(s) of Funding: USDA Specialty Crop Block Grant # USDA-AMS-SCBGP-2016
Biochar has been shown to improve soil conditions such as cation exchange capacity, porosity, pH, and beneficial microbial activity, and to suppress infection by soil-borne pathogens, but it has received relatively little attention in the horticulture industry. Two experiments were conducted in a greenhouse to determine the potential of using biochar as a soil amendment for northern highbush blueberry (Vaccinium corymbosum L. ‘Legacy’). In Expt. 1, plants were fertilized once per week with a complete fertilizer solution (30–10–10) and irrigated twice per week. In Expt. 2, plants were fertilized once per month with 600 ppm of ammonium sulfate and irrigated three times per week. In both cases, the plants were grown in 4-L pots filled with soil (sandy clay) only or with soil amended with biochar or a biochar/bokashi blend at rates of 10% or 20% by volume. Half of the plants in each soil treatment were then inoculated with Phytophthora cinnamomi, which causes root rot. In the absence of P. cinnamomi, plants amended with 20% biochar or 10% or 20% biochar/bokashi blend had greater leaf area and 30% to 70% more total dry weight than those amended with 10% biochar or soil only. The biochar amendments also increased soil aggregation and root colonization by ericoid mycorrhizal fungi. The percentage of roots colonized by mycorrhizal fungi was ≤ 10% in soil only and ranged from 54% to 94% with the amendments. Plants inoculated with P. cinnamomi were stunted and showed typical symptoms of root rot. Root infection by the pathogen negated any growth benefits of biochar or biochar/bokashi and was greater in plants grown with the amendments than in those grown without them. Overall, amending soil with biochar appears to be a promising means of promoting plant growth and mycorrhizal colonization in northern highbush blueberry, but it may not suppress phytophthora root rot.

**Specified Source(s) of Funding:** Family Forests of Oregon

9:45 AM – 10:00 AM

**Evaluation of Mechanically Harvested Southern Highbush Blueberries (Vaccinium corymbosum L.) Advanced Selections for Fresh Market**

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Hamid Ashrafi
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The predominant harvest method of blueberries, is hand harvesting. Production of southern highbush blueberries (SHB) by
southern states (Florida, Georgia, and North Carolina) makes up 26% of U.S. planted acreage and 20% of blueberry production. Hand harvesting blueberries increases production cost and risk of disease, lowering producer profit margins. In addition, hand picking is slower and more laborious than mechanical harvest (MH). These attributes in conjunction with competition among southern states for labor forces necessitates new strategies for blueberry production and harvest. Our objective was to evaluate advanced selections for MH by simulating blueberry growers’ conditions using a mechanical harvester and sorting the fruit using color and soft sorter packing line. Thirteen five-year-old SHB advanced selections (NC4360, NC4385, NC4622, NC4638, NC4671, NC4676, NC4982, NC4984, NC4992, NC4994, NC4995, NC4996, and NC4998) and control SHB cv. ‘Reveille’ were used in a replicated trial from 2015–16. Fruit were harvested up to four times during the harvest season via Little Blue BEI harvester. Harvester efficiency was evaluated for fruit ground-waste, plant debris, and yield of acceptable fruit. Fruit quality was measured for berry weight, firmness, color, and appearance. Postharvest storage amenability was evaluated after a week at 4 °C. Yield evaluations of consumer acceptable fruit after MH, showed that NC4360 had significantly higher yield than eleven other cultivars; NC4994 was not significantly different from the lowest yielding accession. NC4994 had the greatest average berry weight over the two years of study, followed by NC4360, both were significantly greater than nine other accessions. Further, NC4994 and NC4360 had the largest berry latitudinal diameter. The relation of berry weight and diameter to percentage of acceptable berries after MH is an important consideration for suitability of cultivar for MH. Interestingly, fresh fruit firmness was negatively correlated with fruit softness after storage; berries of accession NC4992 had significantly greater fresh fruit firmness and had significantly higher quality berries and least weight loss post-storage. In 2017, hyperspectral transmittance imaging showed NC4992 had the least bruising index compared with Reveille and 30 other described firm accessions. Harvester performance evaluation indicated that the average ratio of harvested consumer-quality fruit to green or soft fruit was 3:1. NC4996 had significantly less soft and immature fruit to acceptable berries harvested at 1:7.5, all other accessions were less than 1:5. Accession evaluations show promise in cultivar adaptability to MH. Overall, accession 4992 has potential of being named as a new cultivar suitable to MH and storage.

Specified Source(s) of Funding: This research was funded by the North Carolina Blueberry Council, the North Carolina Department of Agriculture and Consumer Services, and the North Carolina State University Agriculture Foundation

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**Postharvest 1**

**Moderator:** Zi Teng  
University of Maryland, College Park, MD, USA

**8:45 AM – 9:00 AM**

**Identity, Prevalence, and Chlorine Demand of Major Organic Compounds in Fresh Produce Wash Water**

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USDA-ARS, Beltsville, MD, USA

Large quantities of spent water heavily loaded with plant-derived organic compounds are generated during fresh-cut produce washing process. The significant chemical oxygen demand (COD) and chlorine demand (CLD) arising from those compounds complicate the safe reuse of the wash water. Thus, identification of the major chemicals contributing to COD/CLD will provide valuable information for improving the overall food quality and safety of fresh-cut produce. This study aims to characterize the chief sources of COD and CLD occurring during fresh-cut produce washing. Water samples, prepared by washing diced cabbages, were fractionated through centrifugation, ultrafiltration, and solid phase extraction. Sugars, organic acids, and phenolics were profiled by HPLC, and proteins and peptides were extracted directly from the wash water. Regression equations were established to predict the time-dependent CLD of each identified compound at their respective concentrations. Results revealed sugars as the major contributor to COD (81.6%), followed by proteins/peptides (5.3%), organic acids (3.6%), and phenolics (0.5%). In contrast, contributions to CLD ranked roughly as proteins/peptides > phenols > organic acids > sugars, although this ranking varied over time. Proteins/peptides accounted for approximately 50% of the total CLD during the cabbage washing process. Phenols reacted rapidly with chlorine, contributing to 21% of the total CLD at 5 minutes, but this percentage diminished over time as other compounds reacted continuously. Organic acids (citric, malic, oxalic, and ascorbic) and sugars (fructose and glucose) exhibited a gradual pattern of reaction, making up for 22% and 16%, respectively, of the total CLD at 2 hours. Collectively, the identified compounds...
Comparison of the Browning Potential of Fresh-cut Romaine Lettuce during Cold Storage

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Fresh-cut, ready-to-eat, packaged lettuce has become increasingly popular in the United States; however, this product is highly perishable and browns quickly with a relatively short shelf-life. The selection of cultivars with improved quality and less cut-edge browning could help strengthen and expand the fresh-cut lettuce industry. The objective of this study was to characterize the quality and browning potential of 15 Romaine lettuce cultivars: Braveheart, Clemente, Green Forest, Green Towers, Heart’s Delight, King Henry, Lobjoits, Paris Island Cos, PI 4912242, RH11-1506, Siskiyou, SM13-R2, Sun Valley, Tall Guzmaine, and Triple Threat. Lettuce cultivars were selected, grown, and harvested by the United States Department of Agriculture (USDA) lettuce breeding program in Salinas, CA. Lettuce was shipped to the USDA Food Quality Laboratory in Beltsville, MD for processing, packaging, and shelf-life assessment. Romaine lettuce was trimmed, cut into 2.5 x 2.5 cm slices, washed for 30 seconds in a 100 mg·L⁻¹ free chlorine solution adjusted to pH 6.5, centrifuged for 2 minutes at 666 revolutions/minute, and packaged in polypropylene bags with a film oxygen transmission rate at 5 °C of 16.6 pmol O₂ s⁻¹ m⁻² Pa⁻¹. Packaged lettuce (4 replicates) was stored at 5 °C for up to 14 days. The cut lettuce pieces were analyzed for sensorial quality attributes (freshness, browning, overall quality, and off-odor), head-space gas composition (O₂, CO₂), and color. A new image analysis tool was developed to quantify the browning severity in cut lettuce pieces using high resolution images taken under controlled lighting and analyzed using a smart segmentation computer software (Image Pro Premier).

Sensory results showed that ‘Clemente’ had the lowest browning score (16.0 ± 4.0) and highest overall quality score (75.2 ± 9.1), while Triple Threat had the highest off-odor score (74.2 ± 12.2) and lowest overall quality score (17.3 ± 15.7) after 14 days of storage. Image analysis confirmed that ‘Clemente’ had less extensive browning than Triple Threat, as demonstrated by the amount of lettuce leaf pixels that had a brown color after 14 days of storage (4.7 ± 0.8% for ‘Clemente’, 15.1 ± 3.0% for ‘Triple Threat’). ‘Triple Threat’ also had the largest headspace CO₂ concentration compared to the other cultivars (12.4 ± 0.9% CO₂ after 14 days), indicating that this variety had a higher respiration rate. These results and the image analysis tool developed in this research can be used in the selection and development of new Romaine lettuce cultivars with improved quality.

Vapor Phase Application of Volatile Phenols Inhibits Growth of Botrytis Cinerea and Reduces Disease Incidence of Strawberry Fruit

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Postharvest losses of strawberries and other horticultural small fruits is estimated to be as high as 25% due to disease, dehydration and over ripeness, resulting in economic losses to farmers and consumer dissatisfaction. Both physiological and environmental factors contribute to the limited storage life of fresh fruit particularly when the fruit becomes overripe and begins to show symptoms of disease. In this study, a series of volatile monoterpene and ethyl phenols known for their antimicrobial properties were tested to determine their growth inhibitory effects on the fungus Botrytis cinerea (gray mold), the most common postharvest spoilage organism in strawberry. In a two-factor three-level experimental design, compounds were tested at three concentrations and three temperatures (4, 10, and 22 °C) for growth inhibition of a pure culture of B. cinerea, and for disease incidence of strawberry fruit inoculated with the fungus. The experiment was conducted in Magenta boxes with the volatile phenol compounds applied at specific concentrations to filter paper discs fixed to the inner lid. The concentration of volatile phenols in the box was determined by SPME-HS using a Shimadzu TQ8040 GC-MS. Results indicated that fungal growth inhibition and fruit disease incidence were correlated with the vapor pressure of the volatile phenolic compounds tested.

Specified Source(s) of Funding: Teaching Assistantship

Role of Hexanal Based Formulations in Enhancing the Shelf Life of Nectarines

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An asterisk (*) following a name indicates the presenting author.
Oral Presentations

Postharvest technologies play a key role in enhancing shelf life and maintaining quality characteristics of tender fruits such as nectarines [Prunus persica (L.) Batsch var. nectarina]. This research investigated the effects of an ‘Enhanced Freshness Formulation’ (EFF) with hexanal as the key ingredient to improve shelf life of nectarines. Preharvest sprays of EFF on ‘Fantasia’ nectarines, conducted at two commercial orchards in the Niagara region, ON, showed a general improvement in shelf life. Application of EFF delayed the incidence of chilling injury symptoms (internal browning and mealiensess/wolliness) by one week. Treated fruits maintained significantly higher firmness until 38 days postharvest. There were no differences in total soluble solids, titratable acidity and color values between treated and control fruits, suggesting an otherwise normal ripening behaviour. The volatile analysis study (GC-MS) indicated for the first time that hexanal is naturally present within the nectarine fruit. Further, it was observed that reduced levels of volatile compounds associated with fruit ripening such as lactones, and an increased level of acetates associated with unripe fruit, were present in EFF treated fruit. qRT-PCR was conducted to evaluate the expression levels of 22 genes potentially involved in ripening, to understand the regulatory effects of the hexanal formulation. EFF application induced a highly significant reduction in transcript levels of three Phospholipase D genes, five N-glycoprotein group genes, and other genes involved in ripening and softening processes. These findings indicate that, a delay in the ripening process caused by EFF, may be associated with the modulation of the expression of key ripening related genes, enhancing shelf life and quality of nectarines.

Specified Source(s) of Funding: IDRC (International Development Research Center), Canada

9:45 AM – 10:00 AM

Quantitative Evaluation of Phenolic Compounds and Anthocyanins Reveals Their Phenotypic Variation in Apples

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An asterisk (*) following a name indicates the presenting author.
Light-emitting diodes (LEDs) becomes popular supplemental lighting (SL) in greenhouse because of high illuminating efficiency without compensating crop productivity. Accumulation of phytochemicals can be also induced by LEDs with specific spectrum in many crop species. Besides phytochemicals, mineral nutrients are essential for human nutrition and contribute to the quality and flavor of tomatoes. Ion uptake, partitioning, and assimilation are mediated by phytochrome, whose actions highly depend on red (600–700 nm) and far–red (700–750 nm) light. The objectives of this study were to determine how red and far-red light affects fruit mineral composition and taste of greenhouse tomato. ‘Merlice’ scions grafted onto ‘Maxifort’ rootstocks were supplemented with (FR, 29% far-red: 71% red) or without (R, 100% red) far-red LEDs lighting, compared with the most common SL, high-pressure sodium (HPS) lamps. Tomatoes at the stage 6 were selected for mineral and sensory evaluation. The concentration of nitrate, nitrite, sulfate, phosphate, chloride, sodium, potassium, magnesium, and calcium in fruit were determined by ion chromatography. The ends of the tomatoes were cut off and then the tomatoes were cut into fourths. Panelists were given one piece of each sample, sequentially with sample order being randomized, and were asked to rate the degree of liking (DOL) regarding aroma, sweetness, saltiness, acidity, and texture on a 9-point scale as well as aroma, sweetness, saltiness, acidity, and texture on a 5-point [just about right (JAR) scale]. The panelist was given water and a cracker to cleanse their palate between samples. When complete, the panelist was given a $5 gift card as reward. The concentration of sodium, nitrate, and dry matter ratio were increased significantly by FR, compared to R and HPS. Interestingly, there was a significant difference between the samples for DOL on aroma (FR was rated higher than R), sweetness (FR was rated higher than HPS and R), saltiness (FR was rated higher than HPS), acidity (FR was rated higher than HPS and R), and texture (FR was rated higher than R). Like DOL, there was a significant difference between the samples for JAR on sweetness (FR was rated higher than HPS and R), and texture (FR was rated higher than R). Our results suggest that supplemental lighting with far-red LEDs induces the accumulation of sodium and dry matter in fruit, and that customers can tell the chemical differences from aroma, sweetness, saltiness, acidity, and texture.

Specified Source(s) of Funding: NE-1335 Resource Management in Commercial Greenhouse Production

1:30 PM – 1:45 PM

**Daily Light Integral Supplements Alter Key Flavor Volatiles in Hydroponically Grown Basil**

Hunter Hammock*

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The University of Tennessee, Knoxville, TN, USA

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Light quantity, quality, and duration are three primary factors that impact plant growth and development. Light-emitting diodes (LEDs) offer control for each of these parameters and allow commercial growers to optimize biomass yield and plant quality throughout growing seasons. While many studies show LED supplementation is useful for high-value specialty crop production, research is needed to determine the value and efficacy of LED lighting systems in comparison to traditional lighting systems. Research determining the impact of daily light integral (DLI) and spectral distribution on secondary metabolism and flavor volatile production could be of value to producers. The objective

*An asterisk (*) following a name indicates the presenting author.
Oral Presentations

1:45 PM – 2:00 PM

Morphology and Growth Rate Responses of Red Lettuce to Dynamic Spectral Changes in Indoor LED Sole Source Lighting
Hans Spalholz*
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Ricardo Hernández
North Carolina State University, Raleigh, USA

The use of static or fixed spectral recipes is the predominant strategy for illumination in the indoor crop production industry, regardless of lighting technology used. However, with LED fixtures, it is possible to change the emitted spectrum at different plant growth stages (dynamic spectral recipes) in order to maximize plant biomass and phytochemicals. The objective of this experiment was to compare the effects of fixed and dynamic spectral recipes and end of day far-red (EODFR) light using different percentages of blue (B) and red (R) photon flux (PF) ratios to produce ‘Red Oakleaf’ lettuce. Plants were grown for a total of 47 days with four treatments consisting of two fixed spectral recipes: 1) 20B:80R and 2) 20B:80R–EODFR; and two dynamic light recipes 3) 20B:80R–EODFR (day 3–19) followed by 100B (day 20–39) (20B:80R–100B), and 4) 20B:80R+EODFR (day 3–19) followed by 100B-EODFR (day 20–39) (20B:80R–100B-EODFR). From day 3–11 plants were provided with 100 µmol·m⁻²·s⁻¹ photosynthetic photon flux (PPF) for 18 h and increased to 200 µmol·m⁻²·s⁻¹ PPF for 18 h from day 12–47. For treatments that included EODFR, far-red light consisted of 6 µmol·m⁻²·s⁻¹ for 30 min. From day 40–47 a “finishing” light recipe (50B:50R) was applied to all treatments to evaluate anthocyanin accumulation in the plant. Plants in all treatments had no significant differences in shoot fresh mass. Plants from the dynamic 20B:80R–100B treatment had 12% greater shoot dry mass than the static treatment of 20B:80R. Dynamic treatment 20B:80R–100B–EODFR plants had 64% longer stem length and 109% greater stem fresh mass, respectively, than plants in 20B:80R. Stem elongation altered the leaf dry mass:stem dry mass ratio resulting in 20B:80R–100B–EODFR having the lowest ratio and 20B:80R having the highest ratio. In terms of canopy diameter, 20B:80R–100B was 26% larger than 20B:80R plants. There were no differences in leaf area and leaf net photosynthetic rate. These results demonstrate that dynamic spectral recipes can be used to significantly impact plant morphology and growth while using similar power consumption.

Specified Source(s) of Funding: USDA NIFA, project 1007454

2:00 PM – 2:15 PM

Refined Spectrum of Growing Light Could Improve Photosynthetic Rate
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Green light has lower leaf absorptance than red and blue light, and therefore is often considered to be less photosynthetically efficient at the same photosynthetic photon flux density (PPFD). However, green light can penetrate deeper into leaves and excite deeper cell layers more effectively than red and blue light. We hypothesized that, at high PPFD, green light may excite more leaf cells than red and blue light, and may achieve a higher leaf photosynthetic rate. To characterize the interactive effect of light quality and intensity, we explored the effect of light quality and PPFD on photosynthetic rate. Photosynthetic rate of ‘Green Tower’ lettuce was measured under different PPFDs of red, blue and green light, and photosynthesis-light response curves were fitted for the three colors. The maximum quantum yield of photosynthesis (mles of CO₂ fixed per mole of photons) was determined as the initial slope of the light-response curve. To account for differences in absorbance among the three colors, data was expressed both on an incident and absorbed PPFD basis. At low PPFD, plants under green light had the lowest photosynthetic rate among plants under red, blue and green light. The maximum quantum yield of photosynthesis was significantly higher under red than under blue or green light, indicating that the lower photosynthesis under green light is not only due to lower
Absorptance, but also to less efficient use of absorbed photons. At PPFD above 800 µmol·m⁻²·s⁻¹, however, photosynthetic rate under green light was higher than under red and blue light, likely because red and blue light were absorbed by the top cell layers of the leaf. This likely saturated the reaction centers in those cells, while deeper cell layers receive few photons. Green light, on the other hand, penetrates deeper into the leaf and excites more cell layers than red and blue light. Consequently, a higher PPFD is required for green light to saturate a larger numbers of reaction centers. Because green light can effectively excite more photosynthetic reaction centers, the light saturation point and light-saturated photosynthesis under green light are likely higher than those under red or blue light. In conclusion, green light is more effective at driving photosynthesis at high PPFD than red and blue light. This knowledge could lead to refined design of LED grow lights that will enhance the light use efficiency, reduce energy cost, and ultimately reduce production cost for greenhouse growers.

Specified Source(s) of Funding: American Floral Endowment

Oral Presentations

2:15 PM – 2:30 PM

Growth and Subsequent Flowering Responses of Annual Bedding Plants under Sole-source Lighting at Least Partly from White Light-emitting Diodes

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A mixture of blue (B, 400–500 nm) and red (R, 600–700 nm) radiation used for horticultural applications makes plants appear purplish, causing difficulties in detecting nutritional deficiencies, disease, and physiological disorders compared to a broad (white) spectrum. White light-emitting diodes (LEDs) have a high efficiency, but little research has been published about their use in sole-source lighting of plants. We grew seedlings of begonia (Begonia x semperflores), geranium (Pelargonium xhortorum), petunia (Petunia ×hybrida), and snapdragon (Antirrhinum majus) at 20 °C under six sole-source LED lighting treatments with an 18-h photoperiod. Six treatments delivered a photosynthetic photon flux density (PPFD) of 160 µmol·m⁻²·s⁻¹ using B (peak = 447 nm), green (G, peak = 531 nm), R (peak = 660 nm), and/or mint white (MW, peak = 558 nm) LEDs, which emitted 15% B, 59% G, and 26% R plus 6 µmol·m⁻²·s⁻¹ of far-red radiation. The lighting treatments (with percentage from each LED in subscript) were MW100, MW75R25, MW45R55, MW25R75, B20G40R40, and B15R85. At the transplant stage, seedling height, total leaf area, and fresh and dry weight were similar among treatments in all species except for seedling height of snapdragon. In snapdragon, seedlings grown under MW100, MW75R25, and MW25R75 were 26-33% taller than those grown under B15R85. Unexpectedly, when petunia seedlings were grown longer (beyond the transplant stage) under the sole-source lighting treatments, the primary stem elongated and had flower buds earlier under MW100 and MW75R25 compared to under B15R85. We conclude that B+R and MW LEDs have generally similar effects on seedling growth and morphology at the same PPFD when they emit a similar portion of B radiation, but MW LEDs can cause stem elongation and promote flowering in some species.

2:30 PM – 2:45 PM

Effects of Supplemental UV-B Radiation and PPFD on the Growth and Nutritional Quality of Sweet Basil

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Sweet basil (Ocimum basilicum) is widely used as a culinary herb and medicinal plant due to its unique aromatic flavor and relatively high content of phenolic compound. Effects of supplemental ultraviolet (UV)-B radiation and photosynthetic photon flux density (PPFD) on the growth and nutritional quality of green basil ‘Improved Genovese Compact’ and purple basil ‘Red Rubin’ were evaluated. The experiment was setup in a 2 × 5 full factorial split-plot design with light intensity as the main plot and UV-B radiation as subplot. Uniform basil seedlings with one pair of fully-expanded true leaves were transplanted and moved into a walk-in growth room for two PPFD treatments, 160 and 224 mmol·m⁻²·s⁻¹. Five or two days before harvest, basil plants were applied with one of the five supplemental UV-B radiation levels (no UV-B radiation, control; UV-B radiation of 1 h per day for 2 days, 1H2D; 1 h per day for 5 days, 1H5D; 2 h per day for 2 days, 2H2D; and 2 h per day for 5 days, 2H5D). All plants were sub-irrigated as needed using a nutrient solution with electrical conductivity of 2.0 dS·m⁻¹ and pH of 6.0, and the room temperature was maintained at 23.9±2.1 °C (day/night). The results showed that 2H5D treatment significantly decreased the net photosynthetic rate, transpiration rate, stomatal conductance, and Fv/Fm of green and purple basil plants by 68%/70%, 55%/68%, 65%/76%, and 9%/12%, respectively, and PPFD had no effects. Plant height, total leaf area, and shoot FW and DW of green and purple basil plants were decreased by supplemental UV-B and lower PPFD treatments, and no interactive effects were observed. The shoot dry matter percent of green and purple basil plants were increased by 14% and 19%, respectively, under 2H5D UV-B treatment compared with control. The anthocyanin, total phenolics, and flavonoid concentration of purple basil were slightly decreased by 14% and 19% compared to control. The anthocyanin, total phenolics, and flavonoid concentration of green basil plants under supplemental UV-B treatments were enhanced by 18%-22%, 35%-126%, and 80%-169%, respectively, whereas anthocyanin concentration of purple basil plants showed no difference, and phenolic and flavonoid concentration of purple basil were slightly decreased under 1H2D treatment. Considering the yield reduction and
nutritional content enhancement of basil plants by supplemental UV-B radiation, 1H2D/1H5D UV-B treatments with PPDF of 224 mmol·m^{-2}·s^{-1} was recommended for green basil production under controlled environment, and supplemental UV-Bradiation was not recommended for purple basil production.

_Specified Source(s) of Funding: USDA National Institute of Food and Agriculture Hatch project TEX090450_
Emerging Pests and Diseases of Date Palm (Phoenix dactylifera L.)

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Robert Krueger*
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The United States date industry is small and specialized, requiring specific climatic conditions found only in a limited area in California and Arizona. While the industry has benefitted from low pest and disease pressure that is supported by Federal and State phytosanitary regulations, some pests and diseases have recently been reported from California or have become more prominent in other areas and could inadvertently be introduced to California or the date production area. These are outlined here. Two species of palm weevil (Rhyncophorus sp.), which are highly destructive of date palms and other Arecaceae, have recently been reported from California. One, R. vulneratus, has been eradicated, whereas the other, R. palmarum, remains established approximately 120 miles from the date production area. Palm weevils are destructive on their own but also vector the nematode-associated red-ring disease. The red palm mite, Raoiella indica, has not yet been reported from the date production area but is present in other parts of the United States, Mexico, and the Caribbean Basin. The Giant Palm Borer, Dinapate wrighti, is present in the date production area but is not a problem in healthy, well-maintained orchards; however, periods of stress can cause outbreaks. Fungi are the predominant pathogens of date palms, the most important being caused by Fusarium spp. Bayoud, caused by F. oxysporum f sp albiddensis, is the most devastating disease of date palms worldwide but is confined to North Africa. F. oxysporum f sp canariensis is endemic in coastal California but has not become established in the date production area. Recently a different form, F. oxysporum f sp palmarum, has been reported from Florida. Both of these forms can kill date palms. Diseases of date palms associated with Candidatus Phytoplasma sp. (CP) have been reported from the Middle East, Florida, and Texas, but are not known to occur in California. CP asteris is associated with the Al-Wijam disease in Saudi Arabia, whereas CP cynodontis is the causal agent of white-tip dieback and slow decline in Sudan. Lethal yellows (LY), caused by CP palmae, is a devastating disease of coconut and Phoenix sp. are also susceptible. This phytoplasma has been confined to the Caribbean Basin, but a different subgroup of the LY phytoplasma is associated with Phoenix Palm Decline, reported in Texas and Florida. Additional uncharacterized phytoplasmas have been associated with declining palms in Florida and Mexico.

1:30 PM – 1:45 PM

Effect on Orange Fruit/Juice Quality

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Custis greening disease or huanglongbing (HLB) is devastating the citrus industry in Florida and elsewhere around the world. The presumed pathogen is Candidatus liberibacter asiaticus (CLas), vectored by a psyllid, Diaphorina citri. The disease weakens and eventually kills citrus trees, but in addition, affects the quality of the fruit. Oranges, symptomatic for the disease, are smaller and greener than healthy fruit and are often asymmetrical. Since the disease affects the phloem, the fruit may not be getting normal nutrients and hormones and appear slow to mature. Thus, the disease effects on quality are greater earlier in the season. HLB-symptomatic fruit generally contain less sugars, higher acidity, higher bitter limonoids and astrigent flavonoids than do healthy fruit or asymptomatic HLB fruit. Studies on the juice oranges, ‘Hamlin’ and ‘Valencia’ showed in the season. HLB-symptomatic fruit contain less flavonoids than do healthy fruit or asymptomatic HLB fruit. Preharvest fruit drop is associated with this disease and fruit that are loose on HLB trees (abscission zone partially formed) have the more flavor degradation compared to fruit that are tightly held on the tree. The amount of CLas in the fruit juice correlates with sour, bitter and astrigent flavor characteristics, typical of HLB-affected oranges.

Specified Source(s) of Funding: Southern Gardens Citrus Nursery

2:00 PM – 2:15 PM

Optimizing Quality of Fresh Cut Mangos

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Oral Presentations

Specified Source(s) of Funding: Southern Gardens Citrus Nursery
Mango fruit have always been considered a desired addition to the growing fresh-cut fruit industry. However, unlike apples or melons, mangoes are challenging to process as fresh-cut because they ripen unevenly. A market survey was performed in 2017 in California and Florida to find that most fresh-cut mangoes available to the consumer were often too firm and too sour (less mature than for optimal eating). The objectives of a follow-up study were to find a compromise to process fruit that are ripe enough for optimum taste and texture, and to develop postharvest treatments (coatings or modified atmosphere) that would provide a desired shelf life of 14 days. Imported mangoes were obtained from tropical fruit importers. Upon arrival, fruit were ripened at room temperature, and firmness was monitored until three firmness groups were obtained: 25 N, 30 N and 35 N. Processed fruit were stored in commercial containers (clamshells) for fresh-cut fruit at 5 °C. Fruit cut at 35 N firmness had the least browning, translucency and fermented off flavor, and the greatest cut edge sharpness after 9 days in storage, all positive quality attributes of fresh cut mangoes. Calcium ascorbate, polysaccharide coatings and modified atmosphere will be tested to extend ripe fruit shelf life. Promising maturity and treatment protocols will be transferred to the fresh-cut mango processing industry.

Specified Source(s) of Funding: National Mango Board

Oral Presentations

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The current USDA-ARS Tropical Agriculture Research Station’s (TARS) cacao (Theobroma cacao L.) collection in Mayaguez, Puerto Rico, consists of 262 clonally propagated accessions. Each accession is represented by six individual trees grafted onto a common ‘Amelonado’ seedling rootstock and planted in a completely randomized block design with three blocks and two trees per block. Most of the accessions were established in 2001 and all are established with a spacing of 2 m between plants and rows under irrigation and in full sun. Data being collected include: black pod disease reaction, production, pod index, as well as liquor and chocolate qualities. Phenotypic traits such as the length, width, weight, shape, and color of pods, husk weight and number of seeds per pod are also measured. In 2010, all replicate trees for the existing 154 clones in the collection at the time were fingerprinted using 15 microsatellite markers. Intraplant error (mislabling among replicate trees) and synonymous sets (unique accessions with identical genotypes) were identified. The average number of alleles and gene diversity estimates indicate good genetic diversity representativeness in the collection. Several genetic gaps in coverage have been identified, including underrepresented genetic populations and efforts are currently underway to introduce diverse accessions into the collection. Twenty ancient Criollo accessions were recently incorporated into the collection to fill a specific gap. Fingerprint profiles for cacao accessions as well as voucher images showing flowers, pod shape, color, texture and size as well as bean shape color and size for most accession are available through the USDA, National Plant Germplasm System, Germplasm Resources Information Network (GRIN-Global) database (http://www.ars-grin.gov/).

Recent cacao research focused on field experiments to compare performance of 12 cacao varieties propagated by grafting vs. somatic embryogenesis. This work showed that although there were significant differences between plant propagation treatments for some of the variables measured, these were not of a magnitude that would preclude the use of somatic embryogenesis as a viable propagation system. Ongoing collaborative work on evaluation of new disease-resistant clones for yield performance and bean/chocolate quality along with the contribution of propagative material from the USDA-ARS cacao germplasm collection in assisting cacao growers in Puerto Rico recover from damages caused by Hurricane Maria are discussed herein.

Classification and Origins of Cultivated Tea

**Camellia sinensis (L.) O. Kuntze** Based on SNP Analysis

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HortScience 53(9) Supplement—2018 ASHS Annual Conference

An asterisk (*) following a name indicates the presenting author.

Oral Presentations

**Citrus Crops 1**

**Moderator:** Ute Albrecht  
Southwest Florida Research and Education Center, University of Florida/IFAS, Immokalee, FL, USA

1:15 PM – 1:30 PM

**Rootstock Effects on the Metabolite Profile of Field-grown Navel Orange (Citrus sinensis L.) Trees**  
Ute Albrecht*  
Southwest Florida Research and Education Center, University of Florida/IFAS, Immokalee, FL, USA

Indu Tripathi  
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Kim Bowman  
USDA-ARS, Fort Pierce, FL, USA

Rootstock is important for commercial citrus production in Florida and in other citrus production areas around the world. Although the beneficial influence of rootstock on stress and disease tolerance and productivity is clearly documented, the biochemical interaction of rootstock with the scion in a grafted tree has not been much investigated in citrus. In this study, we applied untargeted gas chromatography-time of flight mass spectrometry (GC-TOF MS) to investigate the metabolic influence of four rootstock varieties with different genetic backgrounds on two-year old field-grown ‘Cara Cara’ navel orange (C. sinensis) trees. The rootstocks included were ‘Cleopatra’ mandarin (C. reticulata), ‘Ridge Pineapple’ sweet orange (C. sinensis), sour orange (C. aurantiun), and ‘Swingle’ citrumelo (C. paradisi x Poncirus trifoliata). In total, we detected 500 unique metabolites in leaves and roots; of these, 147 were identified by their chemical structure. The concentrations of 48 metabolites varied significantly among roots from the four different rootstocks. Of the chemically known metabolites, allantoic acid and gamma tocopherol were among the most discriminating compounds. Whereas allantoic acid is implicated in the transport of nitrogen from roots to leaves in other tree species, tocopherols are important plant antioxidants and essential for the proper functioning of carbohydrate metabolism. Discrimination of root samples was mainly due to significantly higher concentrations of these compounds in ‘Swingle’ compared with the other three rootstocks. In contrast, ‘Swingle’ exhibited lowest concentrations of conduritol-beta epoxide, an important inhibitor of beta glucosidases, enzymes that are involved in the chemical defense against pests and pathogens. Other metabolites were found in highest concentrations in ‘Cleopatra’ roots, notably raffinose and myo-inositol. Both compounds are intermediates of the raffinose family oligosaccharides biosynthetic pathway and important osmoprotectants of plant cells. The most dramatic

2:45 PM – 3:00 PM

**Breeding for the Hawaii Anthurium Industry: What Do Flower Designers Need?**  
Teresita Amore*  
Tropical Plant and Soil Sciences, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, HI, USA

The flower breeding program at the University of Hawaii has historically focused on growers’ needs such as increased yield, vigorous growth, and resistance to pests and diseases. Although the Hawaii Floriculture Nursery Association initiated collaboration with floral designers in 2007 to explore and expand the use of Hawaii-produced floral products, a floral design workshop brought growers, designers and researchers together for the first time in 2016, to familiarize designers with the design process with floral designers in 2007 to explore and expand the use of Hawaii-produced floral products. The result of present study demonstrates, that there are four main genetic lineages in the primary gene pool of tea plant. Each lineage has its independent origin and site of domestication. Our result also reaffirms the old postulate that Cambod Assam (C. assamica sub spp lasiocalyx (Planchon ex Watt.) or “Southern form”) is a distinctive member of Assam tea C. assamica (Masters). Research on assessment of intra-varietal genetic diversity and history of domestication, focusing on small leaved China type, is also discussed.

Specified Source(s) of Funding: USDA-NIFA Hatch project HAW09031-H and HAW0868-H managed by the University of Hawaii College of Tropical Agriculture & Human Resources.

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USDA-ARS, Beltsville, MD, USA

Tea is the most widely consumed beverage in the world next to water. Knowledge of genetic diversity is fundamental for improving, conservation and utilization of tea plant [Camellia sinensis (L. )O. Kuntze] genetic resources. However, the distribution and structure of genetic diversity in the primary gene pool of tea plant is poorly understood. One hundred fifty single nucleotide polymorphism (SNP) markers were used to assess the genetic diversity in 710 tea accessions covering a wide geographic origin and morphological variation. Multivariate and Bayesian clustering analysis revealed four distinctive genetic lineages of tea germplasm, corresponding to small leaved China type and three broad leaved Assam type viz. Indian Assam, Chinese Assam, and Cambod Assam. The four groups can freely inter-bred, resulting in a wide array of hybrids in farmer fields and ex situ tea collections. The result of present study demonstrates, that there are four main genetic lineages in the primary gene pool of tea plant. Each lineage has its independent origin and site of domestication. Our result also reaffirms the old postulate that Cambod Assam (C. assamica sub spp lasiocalyx (Planchon ex Watt.) or “Southern form”) is a distinctive member of Assam tea C. assamica (Masters). Research on assessment of intra-varietal genetic diversity and history of domestication, focusing on small leaved China type, is also discussed.
Timing of Asian Citrus Psyllid Sprays to
Canopy Flush Development
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Lukasz L. Stelinski
University of Florida, Lake Alfred, FL, USA

The Asian citrus psyllid (ACP), Diaphorina citri, is the vector for the bacteria Candidatus Liberibacter asiaticus that causes huanglongbing (HLB). It lay eggs on young leaves of new flush in order to reproduce. To minimize ACP population build-up, minimum adults should be present when new flush leaves are developing. On bearing citrus trees the synchronized spring and first summer flushes should be targeted for maximum ACP control. The Citrus Flowering Monitor is an on-line program that determines when citrus flower buds begin to grow and full bloom will occur. Using this model to determine spring bud break, an adult ACP insecticide was sprayed in spring of 2017 and 2018. By monitoring all stages of ACP from this point forward it was determined when a second spray was needed. The two sprays timed in this way provided more than 60 days of reasonable ACP control. This allowed the flush to develop past the stage when adult ACP will lay eggs on it and past the 10% open flower stage when honey bees find citrus to be a preferred nectar source. A similar timing can be developed for the first summer flush. Two sprays for ACP should allow that flush to develop past the susceptible stage for egg laying by adult ACP also. These two flushes produce about two-thirds of the leaf area on a mature healthy citrus tree. Unfortunately HLB affected trees have some additional flush that was monitored and also treated in 2018. This procedure has the potential to minimize the direct reinfection of the new seasons major leaf area during ACP feeding.

Specified Source(s) of Funding: Citrus Research & Development Foundation

Mulching Practices for Sustainable Citrus
Production
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Citrus growers in the foothills of Northern California are challenged by poor soils with low organic matter and fertility, limited water, and high production costs. Many foothill growers use non-traditional practices such as mulching to mitigate these issues. We have been conducting field research in five commercial mandarin orchards to determine the impacts of mulching on tree health, water use, fruit yields and quality. The research questions are to determine if mulching can reduce herbicide, fertilizer, and water use while maintaining or improving soil and tree health and orchard productivity. Mulch is applied annually in the spring, and comprised of 50% composted horse manure and 50% wood chips, placed along the tree row under the canopy. Data collected includes soil moisture status, organic matter, microbial activity, and overall soil health; mulch composition and microbial activity; ambient temperature and relative humidity; tree growth, nutrient status, fruit yields, and fruit quality. This paper will present results of the mulching trials to date. We have observed significantly higher available soil moisture with concomitant impacts on reduction of tree stress in periods of high heat or dry winds. We developed specific mulching methods to prevent the growth of troublesome weeds under the canopy and root sprouts on ‘Cleopatra’ rootstock. We have also learned key lessons on optimal soil conditions and timing of mulch applications.

Specified Source(s) of Funding: California Department of Food and Agriculture Specialty Crop Block Grant Program

Assessment of Tolerance to Huanglongbing in Citrus Scion Genotypes
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Oxidative Metabolism in Greening-affected Fibrous Root Orders in Citrus

Naveen Kumar
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The disease huanglongbing (HLB) continues to devastate the Florida citrus industry, has become widespread in Texas, and infected tree discovery is accelerating in California dooryard citrus. While highly resistant or even immune trees are the long-term sustainable solution, HLB-tolerant planting material will likely be crucial in the near term. In Florida, where ubiquitous infection provides ample disease exposure, some mandarin hybrid cultivars display potentially useful tolerance. At the USDA-ARS, Ft. Pierce, FL, farm, there are several replicated trials of cultivars and advanced selections exposed to endemic HLB that are providing further insights into potential tolerance. In a trial that is in its fifth year in the field, accessions in the least diseased statistical categories include some with predominately mandarin pedigree, one that is predominately pummelo and several with Poncirus in their pedigrees. The susceptible sweet orange ‘Valencia’ remains in the best categories for all traits except that its growth rate declined markedly in the last year. Many of the cultivars and selections displaying tolerance include ‘Clementine’ in their pedigree. A large trial of diverse ‘Clementine’-derived material is being phenotyped and genotyped to identify markers associated with HLB-tolerance in a collaboration between University of California, Riverside (UC Riverside), USDA-ARS, and the University of Florida (UFL), and statistical separation is now apparent for HLB-tolerance parameters after 2.5 years. A large trial of diverse Poncirus hybrids focusing primarily on citranges (sweet orange × Poncirus), another collaboration but led by the UFL, has been in the field for 6.5 years and may also provide markers for HLB-tolerance, as might an adjoining trial of Poncirus and its hybrids, led by UC Riverside. Verification that HLB-tolerance in growth parameters translates into economic-tolerance through adequate crops of high quality fruit with require several additional years of trial data. A new collaborative NIFA grant will capitalize on these plantings and explore juice quality parameters of HLB-tolerant accessions. Single replacement cultivars or complementary cultivars in blends may provide a solution to inadequate supplies of sweet orange and grapefruit juice in FL.

Specified Source(s) of Funding: Citrus Research and Development Foundation

2:15 PM – 2:30 PM

Oxidative Metabolism in Greening-affected Fibrous Root Orders in Citrus

Naveen Kumar*
University of Maryland Eastern Shore, Salisbury, MD, USA

An asterisk (*) following a name indicates the presenting author.
Teaching Methods

Moderator: Natalie Bumgarner
University of Tennessee, Knoxville, TN, USA

1:15 PM – 1:30 PM

You Want Me to Teach Horticulture Where? Developing a Distance Section of a Plant Physiology and Horticulture Course.

Whitney N. Griffin*
Texas A&M University, College Station, TX, USA

Planning, development, and execution of a distance section for a high-enrollment introductory horticulture course. Course content includes plant morphology, plant physiology, metabolic processes, and general horticultural applications in the green industry. Overview of videoing mini lectures, developing interactive learning modules, graphics and animation development, and anticipating future accessibility requirements. The face-to-face course meets university CORE science requirements and thus most enrollees are non-majors. The presenter will provide the project budget, including costs of animation and graphics development and projected annual income from online differential tuition. Tips and tricks for meeting current accessibility requirements and suggestions for accessible assessment activities will be covered.

Specified Source(s) of Funding: Texas A&M University Instructional Technology Services

1:30 PM – 1:45 PM

CEA in the Classroom: Connecting Secondary Students to Agricultural Career Possibilities

Natalie Bumgarner*
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Jennifer Richards
University of Tennessee, Knoxville, TN, USA

Carrie Stephens
University of Tennessee, Knoxville, TN, USA

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James Swart
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Many challenges await agriculture’s next generation including increasing food production while conserving natural resources and meeting food quality and nutrition standards. Compounding these challenges is the insufficient pipeline of students in science, technology, engineering, and math (STEM) entering the field. To address these hurdles in the STEM fields related to agriculture and food production, this project developed innovative agricultural science curriculum and professional development trainings focused on controlled environment agriculture (CEA) and soilless vegetable production systems. The curriculum was designed to use CEA to connect basic science with food production to provide material flexible enough to be used in agriculture education, as well as biology and chemistry classes. By linking agriculture with basic science concepts, the topic of food production becomes applicable to students across a spectrum of STEM classes. This enables students not currently engaged in agriculture to be introduced to scientific, engineering, and technology needs and applications of the CEA field that fit their interest areas. Professional development workshops were also developed to equip secondary agriculture and science teachers with the background and foundation to deploy the new curriculum and connected research questions in their classrooms. Modern agriculture requires skills in production techniques and technology, and this project can equip educators to reach an ever-expanding student audience with interests in both. This

An asterisk (*) following a name indicates the presenting author.
oral presentations will describe the curriculum development process as well as outcomes of professional development workshops and trainings integration of this curriculum with Extension programs.

Specified Source(s) of Funding: NIFA

1:45 PM – 2:00 PM

Effort Portfolios: Student Reflections on Effective Study Strategies in a Plant Identification Course

Cynthia Haynes*
Iowa State University, Ames, IA, USA

For the past five years more than 100 students in Herbaceous Ornamentals (Hort 330) at Iowa State University have practiced several different strategies to learn how to identify plants. Students were asked to summarize and reflect on their efforts and the effectiveness of at least six strategies in an “effort portfolio” at the end of the semester. At least ten strategies were presented to students as options every year. Each strategy was selected to engage students in meaningful and mindful effort while learning about herbaceous plants. Some of the strategies used each year included: perennial poetry, perennial pictionary, perennial garden selfies, practice quizzes, flash-cards, comparison matrix, repetitive writing, perennial designs, and annual videos. Students were asked to reflect on the effectiveness of each strategy on their learning and why (or why not) it was effective. While the effectiveness of each strategy varies with each student, almost all students (> 90%) ranked flash cards, perennial designs, and annual videos as highly effective strategies. All the strategies that students regarded as effective required students to actively engage in meaningful or mindful effort to learn plant identification.

2:00 PM – 2:15 PM

Effectiveness of Using Google Sheets with University Students to Assess Diversity in Vegetable Crops

Chanelle Angeny
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Shelby Laird
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Stephen F. Austin State University, Nacogdoches, TX, USA

In the 2016 spring and fall semesters, students enrolled in Crop Science at Stephen F. Austin State University (SFA) were given an assignment where they were instructed to use Google Sheets to assess diversity of traits in a seed catalog. Students were assessed before and after the assignment on their experience level with agriculture, gardening, and seed catalogs, their comfort level with Google Sheets and Microsoft Excel, collecting and analyzing data, and their opinion on the effectiveness in using multiple people to collect data and using Google Sheets. In total, 102 students assessed 1056 cultivars in Google sheets. Overall, students were able to use Google Sheets to compile data from multiple people to gain insight on which traits occur most often in seed catalogs. All students, agriculture students, female students, and fall semester students showed a higher level of comfort using Google Sheets/ Microsoft Excel after the assignment. The results also showed that students had a better grasp of what a trait was after completing the assignment. Additionally, students created more robust definitions for a trait and a cultivar post-assignment. From the comments provided on the survey, it was evident that students learned about agriculture and gardening, traits and cultivars, how to interpret seed catalogs, how to use technology, and collaboration. This activity could be useful for agriculture educators.

2:15 PM – 2:30 PM

Enhancing Student’s Experiential Learning with a Home Country Urban Food Systems Study Tour

Eleni Pliakoni*
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Cary L. Rivard
Kansas State University, Olathe, KS, USA

Candice A. Shoemaker
Kansas State University, Manhattan, KS, USA

HORT 795 Urban Agriculture Study Tour is a one-credit course that was added to our Horticulture Masters of Science specialization in Urban Food Systems (UFS) in 2015. Through this course students experience the breadth of urban food systems found in large urban settings. Thus far we have led three study tours to Chicago (2015), Seattle (2016) and Honolulu (2017). During pre-tour class sessions, students are assigned sites that they will serve as the discussion leader for, research the sites and present what they have learned in class prior to the tour. During the week-long study tour students and faculty visit up to 15 sites representing as many aspects of an urban food system as possible, such as urban farms and local food-related businesses, community development and social service groups, and not-for-profit organizations. They have the opportunity to learn from farmers, processors, distributors, planners, community activists, and retailers; and subsequently gain awareness of the complexity of issues surrounding urban agriculture and food systems. Students work on a food security project during the tour, assessing each site to its role in contributing to food security in urban areas and then post-tour present their findings in class. Pre- and post-tour surveys are conducted to assess the value addition of home country study tours regarding student-learning outcomes. Students enrolled in HORT 791 Urban Agriculture were used as a comparison group. Additionally, the graduate students that help organize the trip are interviewed, and written feedback is gathered from all the students and faculty that participate. Our data support the educational value of study tours. Students that
participated in the tours demonstrated greater positive changes in confidence to perform UFS skills than students in a traditional classroom setting. The study tour experience fostered development of students’ capacity to collaborate and share knowledge. Students developed their UFS knowledge and professional skills (soft skills) through guided experiences at the tour sites. Our data supports the value of experiential learning through experiencing the actual context of UFSs.

2:30 PM – 2:45 PM

**Developing Appropriate International Horticulture Technologies through the University of California, Davis D-Lab Curriculum**

Erin McGuire*
Horticulture Innovation Lab, Davis, CA, USA
Kurt Kornbluth
University of California, Davis, USA

The University of California, Davis (UC Davis) D-Lab offers an interdisciplinary, design-led approach to solving community challenges through new systems and technologies. At UC Davis the course teaches innovation, creativity and problem solving skills to graduate students. In 2013, the USAID Feed the Future Lab for Horticulture sought to test whether these methods could be effectively used to create a hands-on pathway to new appropriate technologies for small-scale horticulturists in developing nations. Through the work of Kurt Kornbluth, the D-Lab curriculum was modified and implemented at Zamorano University in Honduras and at Kasetsart University in Thailand. Through observation, guided interviews, and post-class surveys, the impact and effectiveness of this intervention was assessed, as well as the method of implementation recorded. Results included students at both universities reporting over 90% increase in their design knowledge and a significant increase in a likelihood of approaching problem solving more creatively. At Zamorano University, community members were able to use many of the technologies created by the students, and in both cases, the university was able to test these new technologies at their demonstration centers. One of the technologies tracked during the evaluation was the vermi-composter. Students first identified the need, which was increased soil health in the permaculture garden on campus while creating a workable vermi-composter that would hold a specific variety of worms. The students also found that the need applied to greater Latin America due to increased pressure to reduce waste through sustainable initiatives. They felt that the composter could address some of this problem by supplying “alternatives to handling organic waste by presenting an option that could be of interest to gardeners that would take advantage of the waste from homes.” The resulting composter is still in use at Zamorano University. This evaluation also took into account positioning within the institution, class space and size, and logistical challenges to establishing a D-Lab course internationally. Results showed that partnering early with academic administrators, providing enough time to students to develop technologies, and establishing community clients, were essential elements to a successful program, along with access to the D-Lab curriculum. Challenges included material costs (and quick access to funds) and more time needed for market analysis. This work exhibits the effectiveness of the D-Lab strategy within the international academic setting, and offers implementation lessons to establish a D-Lab for appropriate horticulture technology design at other universities.

Specified Source(s) of Funding: USAID Feed the Future Horticulture Innovation Lab

2:45 PM – 3:00 PM

**Impact of Implementing a Project across Different Majors to Investigate Low-cost Hydroponic Technique to be Utilized in Ghana**

Uttara Chandani Samarakoon*
The Ohio State University, Wooster, OH, USA
Diana Rose Elder
The Ohio State University, Wooster, OH, USA
Nathan C. Crook
The Ohio State University, Wooster, OH, USA

HORTTEC 2189 Greenhouse Management Practicum, FAES 3797 Ghana Education Abroad, and COMLDR 2530 Introduction to Agricultural Communication, Education, and Leadership (ACEL), are three courses within different majors at the Ohio State University Agricultural Technical Institute with a common approach to teaching: Project Based Learning (PBL). This interdisciplinary approach brought students and professors together to research, develop, and test a low-cost hydroponic system to be utilized by subsistence farmers in Ghana, West Africa. Following the project we evaluated our challenges and successes in researching, developing, and implementing a PBL project to suit the curricular needs of three different disciplines. During Fall 2016 and Spring 2017, our student researchers in HORTTEC 2189 and COMLDR 2530 developed a hydroponic system capable of functioning off an electrical grid, using all locally available materials. An additional undergraduate research PBL was conducted to investigate the feasibility of growing leafy vegetables similar to African cultivars and to determine changes in nutrient and water uptake overtime. In summer 2017, FAES 3797 enrollees traveled to Ghana to help farmers to implement the tested technology to grow leafy vegetables for personal use and for sale. As a result of the project, students from all majors were exposed to issues in global food security and resource scarcity. Students in HORTTEC 2189, who had previous exposure to hydroponics, found new crops that can be introduced to diversify U.S. hydroponic crop production systems and identified challenges in running low-tech hydroponic systems. Students COMLDR 2530 got the exposure to greenhouse crop production and hydroponic techniques that will be useful for them as agricultural classroom and extension educators. This project provided a strong foundation to students in FAES 3797, before dissemination of knowledge in Ghana by providing a hands-on experience from seeding to harvest. Students also identified

An asterisk (*) following a name indicates the presenting author.
common crop production issues during technology transfer across continents. In conclusion, a single PBL provided variable learning outcomes based on the discipline and introduced a real-world experience to the class room.

**Human Issues in Horticulture**

Moderator: Michael Schnelle  
Oklahoma State University, Stillwater, OK, USA

1:30 PM – 1:45 PM

**Jefferson Science Fellowships—A Program Tailor-made for Horticulturists**

Peter Hirst*  
Purdue University, West Lafayette, IN, USA

The Jefferson Science Fellowship (JSF) program provides an opportunity for tenured faculty members to contribute to the policy and decision-making processes in the United States (U.S.) federal government, through one-year placements at the Department of State or the U.S. Agency for International Development (USAID). The degree to which knowledge of horticulture, agriculture and environmental issues impact federal decision-making are immense, but seldom are those in the academic community privy to such processes. The JSF program provides fellows an opportunity to provide input on U.S. international policy and program development and thereby gain experience and viewpoints from a different perspective than usually seen in academia. The JSF program has been in existence for 15 years and has accepted a total of 137 fellows. The fields of engineering and technology have been well represented, but only two JSFs have been horticulturists. Horticulturists have much to offer. For example, many, especially those with extension appointments, have expertise translating science and research information into language that is easily understood by their audience. They also are adept at applying scientific information from many fields of study to a given situation. Horticultural production can often result in high crop values from small land areas, is of high nutrient status and can empower women and youth—these attributes align with many of the goals of USAID. Fellows spend one year on-site in Washington D.C., although extended stays at U.S. foreign embassies and/or missions are possible. The program is a collaborative effort between the U.S. academic community and USAID and the Department of State. Home academic institutions provide salary and benefits while a living allowance is provided through the National Academies of Sciences, Engineering and Medicine. Horticultural scientists have much to offer this program and to gain from it. Increased participation from ASHS members is encouraged.

2:00 PM – 2:15 PM

**World Food Prize Global Youth Institute**

Sarada Krishnan*  
Denver Botanic Gardens, Denver, CO, USA

The Global Youth Institute is an international education program offered by the World Food Prize. Exceptional students from state youth programs as well as international students and their teacher mentors travel to Des Moines, Iowa in mid-October to attend the three-day event at which they interact with World Food Prize Laureates and get the opportunity to explore pressing food security and agricultural issues with international experts, expanding their knowledge on global issues. Students research and select a topic related to poverty, agricultural productivity, and food security and write a research paper, the findings of which they present and discuss with international experts and their peers. The Global Youth Institute serves as a forum for students to connect with other students from around the world, attend symposia featuring discussions by global leaders in food security, and tour agricultural research facilities. Since its inception in 1994, the Global Youth Program has grown tremendously. Among the participating states, Colorado had been missing. Denver Botanic Gardens’ Center for Global Initiatives (CGI) partnering with Colorado State University offered Colorado’s first state youth institute in 2017. The program is expanding in 2018, reaching additional schools and offering a teacher training workshop in the summer to provide high school teachers the tools to administer this program. Details about this program will be discussed.

2:15 PM – 2:30 PM

**Training Horticulture Students through a Charitable Garden Project**

Jacqueline Ricotta*  
Delaware Valley University, Doylestown, PA, USA

Started in 2012 with one acre on the Delaware Valley University campus farm, the Hope for the Harvest garden uses DeVal land to grow fresh, nutritious food for families who are slipping through the food safety net. It is both an educational tool for students wanting experience in vegetable production, as well as a charitable endeavor supported by numerous donors and volunteers. In its inaugural growing season, the garden produced 35,000 pounds of produce. That has since grown to approxi-
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

2:30 PM – 2:45 PM

**Improving Crop Production in the Developing Counties**

Mohammad Babadoost*
University of Illinois, Dept. of Crop Science, Urbana, IL, USA

According to the reports by the United Nations, more than 800 million people in the world in 2016 were chronically undernourished. To establish a sustainable global food security, not only increasing yield and quality of food crops is needed, but also preventing/minimizing losses of the crops and products is essential. Despite losing some of the productive agricultural lands to urban developments throughout the world, there are still considerable land areas with plenty of water that can be utilized for production of food crops. However, despite vast efforts on plant protection, more than 30% of food crops and products are lost to plant pests (diseases, insects, and weeds). The losses are much higher in the developing countries than developed countries. To improve crop production and minimize the losses, establishing/strengthening national agricultural programs is essential. Productive agricultural programs require strong teaching, research, and extension establishments in every nation. Problem-solving in every area of the world should be based on the credible local research, complimented with credible and timely information-delivery to the end users. External helps are valuable, but they will be more productive if the helpers have satisfactory knowledge of the ethnical cultures of the assigned areas. With all international efforts, effective problem-solving in production of food crops, and alleviating hunger problem, in the developing countries will be achieved by local specialists.

2:45 PM – 3:00 PM

**Food Production in Guyana**

Robin Brumfield*
Rutgers, The State University of New Jersey, New Brunswick, NJ, USA

In 2010, the Hydroponic Shade House Vegetable Production and Marketing Project was launched in Guyana in response to the floods and heavily saturated coastal soils to improve the economic welfare of rural households and the disadvantaged through food production and self-employment. The objective of the project, implemented and funded by Partners of the Americas and the Caribbean Self Reliance International (CASRI), was to provide rural households and the disadvantaged with the know-how, guidance and support mechanisms to be self-employed entrepreneurs with sustainable low-cost shade house vegetable production facilities. By 2013, 52 shade houses were established throughout the targeted regions. Today’s market sees knowledgeable consumers, demanding distribution networks and high quality and low price competition from domestic and international suppliers. Therefore, to gain domestic and export markets, suppliers of hydroponic grown crops have to provide the finest with the highest up-to-date quality standards at a competitive price. Suzanne’s Project could help empower female farmers in Guyana through agricultural business management training. The women all completed business plans. Evaluations showed that they felt that the course was very valuable and they wish they had had the workshop sooner. Three of the women want to teach other women what they have learned. They were particularly proud of their mission statements, goals, and the fact that they understand financial statements now. The women feel that the course was very valuable and they wish they had had the workshop sooner. Three of the women want to teach other women what they have learned. They were particularly proud of their mission statements, goals, and the fact that they understand financial statements now. They understand the importance of record keeping to calculate costs and returns and profitability also appreciated networking with each other. They now feel that they can make more income from producing food in shade houses as businesses, than they can in alternative employment opportunities.

**Specified Source(s) of Funding:** Farmer to Farmer Partners of the Americas
Yield and Quality of Sweet Corn Grown with Biodegradable Plastic Mulches
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Washington State University, Mount Vernon, WA, USA

Carol Miles
Washington State University, NWREC, Mount Vernon, WA, USA

Polyethylene (PE) and biodegradable mulches are commonly used for many vegetable crops, but use is relatively new for sweet corn and interest is increasing especially due to decreased days to harvest and water conservation attributes. Biodegradable mulch that can provide crop production benefits and completely biodegrade in the soil after tillage incorporation would serve as a sustainable alternative to PE mulch. We carried out a field experiment in 2017 to compare five potentially biodegradable plastic mulches (BioAgri, Organix, clear Organix, Experimental, and Naturecycle), a cellulose mulch [WeedGuardPlus (100% biodegradable)], PE mulch (non-biodegradable), and a bare ground treatment for their effect on sweet corn (Zea mays cv. Xtra Tender 2171) growth, yield and quality at Mount Vernon, WA, where average air temperature during the growing season was 16.3 °C (range 11 °C to 23 °C). All mulches were black except clear Organix and brown WeedGuardPlus. Weed pressure was minimal throughout the growing season in all mulch treatments except clear Organix. While most mulches remained sufficiently intact until the end of the growing season, clear Organix split, starting shortly after laying, and fresh weight of weeds at 3 weeks after seeding was 39% more compared to the bare ground treatment. Plant height at 90 days after seeding was lowest for plants grown on bare ground (103 cm), intermediate for clear Organix and WeedGuardPlus (average 118 cm) and greatest for all black plastic treatments (average 139 cm). Days to 50% tasseling and 50% silking were delayed for bare ground and WeedGuardPlus by 9 and 13 days, respectively, compared to all other treatments. Marketable ear yield was higher with PE, Organix, and Experimental (average 10.8 t·ha⁻¹), intermediate with BioAgri and Naturecycle (average 9.5 t·ha⁻¹), and lower with bare ground, WeedGuardPlus and clear Organix (average 6.6 t·ha⁻¹). There was no difference among treatments in total soluble solids of kernels (average 15.4 °Brix), but ear length and diameter were 8% smaller on average for ears grown on bare ground, WeedGuardPlus, and clear Organix compared to other mulch treatments. The length of the unfilled ear tip was greater for bare ground (2.95 cm) compared to all other treatments (average 1.2 cm). These results indicate that yield and quality of sweet corn grown with black biodegradable plastic mulches can be comparable with PE mulch, but that crops grown with clear and paper biodegradable mulches may need different management practices than with PE mulch.
high levels in its predominantly grown cultivar Covington. IN symptoms of brown and black areas in the root cortex can only be discovered when the root is thinly sliced at the proximal end of the root. Certain cultivars like Covington are more prone to IN, but various factors that cause this problem continue to be investigated. The goal of our research was to evaluate several preharvest and postharvest conditions and how it affected occurrence of IN. Three replicated field studies in 2016 and two in 2017 were conducted. Application of a high chlorine versus minimal chlorine fertilizers and mowing versus not mowing prior to harvest were the four preharvest treatment combinations evaluated. For the postharvest treatments, 30 roots were obtained from each preharvest plot and placed in 75 °F and 82 °F rooms in 2016, with the addition of a 95 °F room in 2017. Fresh harvested sweetpotatoes were stored in these rooms for duration after harvest of 1/2, 1, 2, 3, and 5 weeks in 2016, and for up to 2 weeks in 2017, then placed in a 58 °F storage room. A control treatment was included where roots were not cured and placed immediately after harvest in a 58 °F storage room. Samples were cut approximately 90 days after harvest and IN incidence and severity recorded. Data were statistically analyzed with SAS Mixed procedure, comparing main effects (preharvest and postharvest) and its interactions. Preharvest treatments showed no differences in the main effects but were significant when combined with postharvest treatments. No mow treatments showed higher incidence than Mowed treatments as temperatures and duration increased in one of the three 2016 studies, increasing from 4% to 6% and 11% when cured for 1/2, 1, and 2 weeks, respectively, then leveling off at 3 and 5 weeks. The no mow treatment showed higher incidence when cured at 85°F (11%) versus 75°F (6%) versus the mow treatment (85°F (6%) versus 75°F (5%), which has similar IN incidence. The same trend was observed in 2017 studies in both locations. The no mow treatments showed higher incidence when curing duration increased from ½ to 2 weeks (6% to 18% in location 1 and 3% to 32% in location 2) while the mowed treatment increased less (3% to 11% in location 1 and 3% to 14% in location 2). When no mow treatment was combined with temperature in 2017 studies, incidence was higher at 85°F (21% and 22%, for locations 1 and 2, respectively) versus 75°F (11% and 10%, for locations 1 and 2, respectively) than the interaction for mow treatment at 85°F (11% and 10%, for locations 1 and 2, respectively), versus 75°F (3% and 8%, respectively) for locations 1 and 2. Postharvest main effects were significant both years at all locations. Curing at 85°F had higher incidence than the 75°F, while the control (58°F) treatment was as low as 0% the second year. Duration of curing treatment from 1/2 to 2 weeks is a key factor, increasing IN significantly at all locations both years.

Specified Source(s) of Funding: NC Sweetpotato Commission

Evaluating Resistance to Verticillium Wilt and Productivity of Grafted Eggplant
Abigail Attavar*
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Carol Miles
Washington State University, NWREC, Mount Vernon, WA, USA

In Washington state Verticillium wilt (caused by *Verticillium dahliae*) negatively affects the productivity of eggplant (*Solanum melongena*). The pathogen colonizes the roots and vascular system, leading to plant wilting and yield loss. This study, done in 2016 and 2017, evaluated the resistance of susceptible eggplant cv. Night Shadow grafted onto five commercial solanaceous rootstock cultivars, Estamino, Java, Meet, Shield and Survivor, and heirloom tomato, cv. Cherokee Purple, for resistance to Verticillium wilt. The study also included non-grafted rootstocks and scion controls. ‘Shield’ was included only in 2017. The field site was naturally infested with *V. dahliae*, 28 cfu·g⁻¹ and 5 cfu·g⁻¹ of soil in 2016 and 2017, respectively. Seedlings were spliced grafted in a greenhouse, healed, and roots were drenched with 5 mL of *V. dahliae* conidial suspension (8 × 10⁶ conidia per mL in 2016 and 2.35 × 10⁶ conidia/mL in 2017) at the time of transplanting to the field. In 2016, Verticillium wilt incidence and severity were noted near harvest (108 DAT) and were lowest for ‘Night Shadow’ grafted onto ‘Estamino’ and ‘Java’ (severity only) and non-grafted rootstocks ‘Estamino’, ‘Java’, ‘Meet’ and ‘Survivor’ (*P = 0.01*). In 2017, disease severity near harvest (103 DAT) was least for ‘Night Shadow’ grafted onto ‘Survivor’ and greatest for non-grafted ‘Meet’ (*P = 0.04*); disease incidence was not significantly different among treatments. AUDPC values were only calculated in 2017 and were least for ‘Night Shadow’ grafted onto ‘Estamino’ and ‘Survivor’. Fruit yield was greatest for ‘Night Shadow’ grafted on ‘Meet’ (*P = 0.03*) in 2016, and in 2017 for ‘Night Shadow’ grafted on ‘Cherokee Purple’ (*P = 0.0003*) for replicates one and three (these replicates exhibited normal growth). In replicates two and four, where plant growth was stunted due to soil conditions, there was no significant difference in fruit yield among treatments. Our results indicate that different rootstocks may interact uniquely and vary with the level of *V. dahliae* infestation and environmental conditions in the field.

4:00 PM – 4:15 PM

Intercropping Winter Greens between Cane Fruit Rows for Year-round High Tunnel Production

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An asterisk (*) following a name indicates the presenting author.
With the help of USDA-NRCS Environmental Quality Incentives Program (EQIP), small acreage growers in New Mexico (NM) may receive funding for installing and operating high tunnels. In Alcalde, NM, a year-round study was designed to compare fruit yield of two varieties of uncovered blackberry canes to those intercropped in a high tunnel. The long-term goal of the study is to create a year-round model of blackberries intercropped with winter greens in a high tunnel. High tunnels are a temporary structure that are passively solar heated. For the study, ‘Chester’ and ‘Triple Crown’ blackberry varieties are being grown at the NMSU Sustainable Agriculture Science Center in Alcalde. Two rows of blackberry canes were planted in a field and two rows were planted in a high tunnel. Each row consisted of replicated and randomized plantings of both blackberry varieties. In winter, four rows, containing randomized plots of ‘Red Russian’ kale and ‘Bloomsdale’ spinach were planted at the base of dormant canes in the high tunnel. Yields of the two blackberry varieties were compared by weight and fruiting date to study how berry yields were affected by the high tunnel winter intercrop. Both varieties of winter greens were harvested, and fresh yield weight were compared to discern fitness as a possible intercrop. Preliminary data indicates that ‘Triple Crown’ canes outperform ‘Chester’ in both high tunnel and field trials. However, a negative impact to high tunnel berry production can be seen in both varieties, possibly due to warmer high tunnel temperatures during the winter. As a winter intercrop, kale appears to be marketable in fewer days and with higher overall yields than spinach. This sustainable agriculture model utilizes intercropping in a high tunnel setting to provide farmers a second crop and year-round utilization of high tunnels. This system diversifies their crops and doubles their land use efficiency and year-round farm income.

4:15 PM – 4:30 PM

**Effect of Plastic Color on Yield and Quality of Eight Broccoli Hybrids**

Brian Ward*
Clemson University CREC, Charleston, SC, USA

Matthew Horry
Clemson, Charleston, SC, USA

Christopher Simmons
Clemson, Charleston, SC, USA

David M. Couillard
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Mark Farnham
USDA-ARS, Charleston, SC, USA

Broccoli consumption and production acreage along the eastern United States is increasing, and growers are looking to capitalize on cultural practices that maximize production. Although broccoli has been traditionally grown on bare ground, there is an increase in production utilizing plasticulture, especially as a second crop after commercial cucurbit and solanaceous crops. This study was implemented to determine yield and quality of the commercial hybrids Bay Meadows, Castle Dome, Belstar, Iron Man, Gypsy, and three experimental hybrids (1, 2, and 3) planted in three environments on black, reflective, and white polyethylene mulch. The trials used a randomized block design and plots were set on 6’ centers as twin rows 14” apart and within row spacing at 6”. Planting dates were 21 Mar. 2016, 19 Sept. 2016, and 21 Sept. 2017. Quality was graded for the traits head extension, head color, head shape, head uniformity, head firmness, head size, head uniformity, bracting, overall quality, plot uniformity and holding ability. Soil temperatures under the plastic across all environments were lowest with reflective, and increasingly higher with white and black, respectively. Air temperatures in the canopy zone directly above the mulches were highest with reflective, and lowest with white. Yield and quality varied among environments and color of plastic mulch. In spring 2016, Gypsy out-yielded all other cultivars on black plastic with a total of 31,972 lb/acre. On reflective mulch, Hybrid 1 had the highest yield of 32,985 lb/acre, and on white mulch, ‘Castle Dome’ was highest at 33,258 lb/acre. Yields were generally better in the fall of 2016, with Belstar outperforming all other cultivars at 41,085 lb/acre. In that same environment, ‘Iron Man’ outperformed all other cultivars yielding 43,097 lb/acre on reflective mulch, while Belstar was the best hybrid on white mulch yielding 37,459 lb/acre. In Fall 2017, ‘Gypsy’ was the top performer on black, reflective and white mulches at 39,706, 35,473 and 37,196 lb/acre, respectively. Quality characteristics varied with regard to cultivar, environment and color of mulch. Results of this trial indicate certain hybrids perform better with regard to yield, quality and earliness depending on the mulch used, which will help growers better plan their future broccoli productions.

4:30 PM – 4:45 PM

**Integrating Cover Crops in High Tunnel Vegetable Production**

Ajay Nair*
Iowa State University, Ames, IA, USA

Kristine M. Lang
Iowa State University, Ames, IA, USA

The environment without rainfall, limited space, and potential climate control in a high tunnel calls for sustainable crop and soil management approaches. With high tunnel production primarily dominated by tomatoes and the potential to grow crops year-round, a cohesive and focused approach is needed to tackle issues that would arise due to continuous crop production under these structures. Some common issues experienced include high salt build up, resurgence of soil-borne and foliar diseases, poor soil structure, lack of microbial diversity, and reduced crop yields. One of the strategies to mitigate these issues would be include cover crops in high tunnels. This study conducted in a 9.1 m x 29.2 m high tunnel for two years at the Horticulture Research Station, Ames, Iowa comprised of three treatments—oilseed radish, yellow mustard, or no-cover crop. Tomato ‘Mt. Spring’ was transplanted after cover crop termination each year. The experimental design was a randomized complete-block design with four replications. Each treatment plot was 3.1 m wide x
Hydroponic Production of Leafy Green Vegetables for Local Foods Market

Chiwon Lee*
North Dakota State University, Fargo, ND, USA

Trends toward local foods are an important aspect of community health and influence factors ranging from human nutrition to economic and environmental sustainability. In response to these movements, new businesses of growing and supplying fresh and nutritious vegetables year-round for local consumption can well be established in any community or region. This study was carried out to evaluate different systems for hydroponic production of leafy greens as well as selection of suitable cultivars. Over 60 different commercial lettuce cultivars were grown in the nutrient film techniques (NFT) as well as hydroponic tub cultures. Cultivars were evaluated for their fresh biomass yield, nutritional quality, growth rate, tendency for bolting, and developing such physiological disorders as leaf margin burns. In general, the hydroponic tub culture allowed faster growth than the NFT system for most cultivars. The tub culture in which seedling plants are anchored on Styrofoam boards and floated on nutrient solution inside tubs (9 plants/tub) is a convenient way of growing healthy plants for small-scale production. Proper balancing of nutrient ions according to the analysis of local water supply is important for optimum plant growth. Temperature and humidity control is essential for the prevention of physiological disorders. Use of artificial lights like LED and LEP may be needed for winter production. Planning and scheduling of leafy green production according to market demand are important. Cultural recommendations for growing lettuce as well as other leafy green vegetables will be discussed.

Specified Source(s) of Funding: NDDA Specialty Crop Block Grant

Genetics and Germplasm 2

Moderator: Elisheba Young
North Carolina State University, Raleigh, NC, USA

3:15 PM – 3:30 PM

Identification of Historic Homestead and Orchard Apple Cultivars in Wyoming

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University of Wyoming, Laramie, WY, USA

There were thousands of apples planted in Wyoming’s orchards and homesteads in the 1800s, many of which are still alive today. The purpose of this research was to identify heritage apple cultivars in Wyoming using genetic fingerprinting (microsatellite) techniques and then use this information to suggest candidate cold-hardy cultivars for specialty crop and breeding programs. Leaf samples were collected from 510 heritage apple trees from 88 sites in 18 cities across Wyoming. In addition, known cultivars from the USDA-National Plant Germplasm System, Seed Savers Exchange and Washington State University apple collections were used as standards to determine cultivar identities. Overall, 335 (65%) of the previously unidentified apples trees matched to 47 known cultivars. Fifteen of these known cultivars comprised over 80% of the samples that were identified, with 14 of those cultivars developed in states and countries with average temperatures or winter conditions similar to Wyoming (including Minnesota and Russia). Seventy one of the heritage trees were the cultivar, ‘Wealthy’, and other commonly identified cultivars were ‘Haralson’, ‘Patten’s Greening’, ‘Yellow Transparent’, ‘Northwestern Greening’ and ‘McMahone’. The popularity of ‘Wealthy’ may be the result of its promotion in Agricultural Extension Bulletins from 1870–1940 and its frequent use in developing novel varieties for Wyoming’s climate. Although many original Wyoming heritage apple trees are reaching the end of their lifespan, many surviving trees continue to produce fruit. These results provide insights into possible cultivars that could be grown in Wyoming and also in other states with similar harsh growing conditions.

Specified Source(s) of Funding: USDA-National Institute of Food and Agriculture and Wyoming Department of Agriculture Specialty Crops Program

An asterisk (*) following a name indicates the presenting author.
Linkage and Association Analysis of Dihydrochalcones in Apple Germplasm and Hybrid Populations
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Dihydrochalcones (DHCs), including phloridzin, sieboldin, and trilobatin are phenolics found in *Malus* species, with phloridzin as the primary form found in most species, including cultivated apple. DHCs in apple have unique chemical properties with commercial and nutritional value. To understand the genetic basis of these DHCs in *Malus*, five F$_1$ populations were developed with a common male parent (*Malus* prunifolia PI 589816). DHC content was measured in each population and we observed segregation of phloridzin, sieboldin, and trilobatin into five distinct profiles, fitting a model for three independently segregating loci. QTL on linkage groups 7 and 8 associated with trilobatin and sieboldin were identified with linkage analysis and association mapping using the USDA *Malus* collection in Geneva, NY.

*Specified Source(s) of Funding:* USDA-ARS Plant Genetic Resources Unit

Development of Simple Sequence Repeat DNA Markers for Muscadine Grape Cultivar Identification
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The University of Georgia, Athens, GA, USA
Patrick Conner
University of Georgia, Tifton Campus, Tifton, GA, USA

Muscadine grapes, *Vitis rotundifolia*, are native to North America and became commercial in the middle of 18th century. Breeding programs have produced large collections of *V. rotundifolia* cultivars and hybrids with other related species. Muscadine germplasm is currently documented through the use of breeding records and examination of morphological traits, which can be both unauthentic and equivocal. In this study, 190 individuals (180 *V. rotundifolia* and 10 *V. vinifera*) were examined with 10 pairs of simple sequence repeat (SSR) primers. A total number of 138 alleles were amplified in the 190 individuals. The number of effective alleles for each SSR marker was on average 5.19, ranging from 2.35–11.16. The SSR profile was used to identify the true-to-type cultivar by estimating pairwise similarity of individuals with the same name as well as by comparing shared alleles of parents and progeny. A total of 75 true-to-type cultivars were identified and homonyms were found exist in 12 cultivars.

In addition, unique barcodes for molecular identity cards for the true-to-type cultivars were established using the fingerprints from those SSR markers. Each muscadine cultivar will have a unique barcode identity card, which can make it much easier for growers to identify muscadine cultivars in the future.

*Specified Source(s) of Funding:* Southern Regional Small Fruit Consortium

Cultivated southern highbush blueberries are among the high value crops in North Carolina with an estimated annual ~$70 M farm-gate value. Blueberry contains many beneficial components like flavonoids, which can help combat cardiovascular disorders, neurodegenerative diseases, diabetes and cancer thus contributing significantly to the current popularity of the crop. Blueberries are members of the Ericaceae family and include several subgenera or sections. *Vaccinium* section *Cyanococcus* is native to North America and all species of this section have contributed to the genetic background of most commercially important cultivars. Traditional breeding efforts to develop superior blueberry cultivars began in 1908 and, as a result, many of today’s cultivars are the product of interspecific hybridization followed by backcrossing. Consequently, modern cultivars are segmental allopolyploids, which share a complex ancestry resulting from the intercrossing of different wild accessions and cultivated varieties. The outbreeding nature of blueberry and the use of inter- and intra-specific hybridization during the past century has generated a lot of speculation about the relationship between the founder species and the modern cultivars. With the advent of next generation sequencing (NGS) technologies, it is currently possible to uncover their interrelation at the whole genome level at a lower cost by sequencing each founder and cultivated species. In this study, using Illumina sequencing, we re-sequenced 28 accessions at 20X genome coverage. The 28 accessions were comprised of 19 different wild and cultivated species from 6 sections in *Vaccinium* that represent 16 diploids (2n = 2x = 24), 9 tetraploids (2n = 4x = 48), and 3 hexaploids (2n = 6x = 72). The 16 diploids represented 12 different species including: section *Cyanococcus* (*V. caesariensis*, *V. darrowii*, *V. elliottii*, *V. fuscatum*, *V. myrtilloides*, *V. pallidum* and *V. tenellum*); section *Batodendron* (*V. arboreum*); section *Herpothamnus* (*V. crassifolium*); section *Hemimyrtillus* (*V. cylindraceum*); section *Pyxothamnus* (*V. ovatum*); and section *Polycodium* (*V. stamineum*). The 9 tetraploids were representative of 6 different species including: section *Cyanococcus* (*V. angustifolium*, *V.
Peach Tree Short Life (PTSL) is a complex disease syndrome caused by different biotic, climatic, and edaphic factors. The PTSL disease etiology is associated with the presence of high population densities of ring nematode [Criconemoides xenoplax Raski syn. Mesocriconema xenoplax (Raski) Loof and de Grisse]. The resulting injury and physiological response to nematode feeding increases susceptibility of peach trees to bacterial canker (Pseudomonas syringae pv. syringae van Hall) or cold injury, or an interaction of both. The genetic basis of tolerance/susceptibility to PTSL in peach is not well understood. Thus, four different F2 families, derived from a cross between a PTSL susceptible rootstock Nemaguard and tolerant rootstock Guardian®, were evaluated for PTSL tolerance in the field, and genotyped using Genotyping by Sequencing (GBS). A meta-analysis approach was used to refine QTL positions detected in family specific genetic linkage maps, and revealed a total of six metaQTLs that largely drive PTSL resistance, two on each linkage groups (LG) 1, 4, and 6. All metaQTLs except PTSL.meta-1.2 showed significant effects on PTSL. Individuals heterozygous for PTSL.meta_1.1, with a haplotype originating from both Guardian® and Nemaguard, exhibited the best phenotypic performance. Both metaQTLs on LG4 exhibited the best PTSL field performance when the haplotype derived from Guardian® was in a homozygous state. Candidate gene analyses in the metaQTL genomic regions detected over 180 resistance genes, including genes associated with resistance to bacterial diseases. A denovo Guardian® genome assembly revealed multiple duplications in resistance genes, most of them in PTSL.meta_4.1 and PTSL.meta_4.2 regions, suggesting a disease resistance hot spots on chromosome 4 of the peach genome. MetaQTLs identified in this work suggested that genomic regions associated with PTSL response in peach are associated with response to bacterial canker as a main cause of death after nematode infection weakens a peach tree.

Specified Source(s) of Funding: USDA-AMS-SCMP-2015 “Short and Long-Term Solutions for Armillaria Rot Rot in Prunus”

4:45 PM – 5:00 PM

Genome-wide Association Study for Brown Rot Tolerance in Peach

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Brown rot, caused by Monilinia spp., is one of the most important diseases for stone fruit worldwide. The fungi affect peach in both pre and postharvest stages and can cause severe yield
An asterisk (*) following a name indicates the presenting author.

HortScience 53(9) Supplement—2018 ASHS Annual Conference
Oral Presentations

4:15 PM – 4:45 PM
Phytopathogens, Plant Production, and Water
Jennifer L. Parke*
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Joyce Eberhart
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Plant pathogens can cause crop losses and reduce the quality of greenhouse and nursery plants. Plant pathogens can also be moved long distances by the plant trade, potentially spreading diseases to new hosts and habitats. Phytophysanitary approaches based on quarantines and end point inspections have reduced but not eliminated the interstate spread of Phytophthora ramorum with nursery stock, for example. It is therefore important for plant production facilities to identify potential sources of contamination and to take corrective measures to prevent disease. We applied a systems approach to identify sources of contamination within horticultural nurseries and demonstrated that irrigation water can be an important source of contamination by waterborne plant pathogens such as Phytophthora and Pythium species. We will present case studies from nurseries in Maryland, South Carolina, Oregon, and California to illustrate how recycled irrigation water contributes to the spread of waterborne pathogens, and show how nursery management practices can reduce disease risk.

Specified Source(s) of Funding: USDA-NIFA-SCRI #2014-51181-22372

Floriculture and Nursery Crops: Nutrition
Moderator: Jennifer Boldt
USDA-ARS, Toledo, OH, USA

3:15 PM – 3:30 PM
Monthly Levels and Criteria Considerations of Nutrient, pH, Alkalinity, and Ionic Variables in Run-off Containment Basins in Ornamental Plant Nurseries
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TriPLICATE water samples were collected monthly from nine waterways (eight recycling containment basins (RCBs) and one stream) on four commercial ornamental plant nurseries from February to July, and from 1 RCB and nursery from April to October. Four RCBs, one per nursery, were actively utilized as an irrigation water source. Analysis was done for 18 water quality variables including ammonium–nitrogen (NH₄⁺ – N), nitrate–nitrogen (NO₃⁻ – N), ortho phosphate–phosphorus (PO₄³⁻ – P), Total phosphorus (T-P), potassium, calcium, magnesium, sulfur, aluminum, boron, copper, iron, manganese, zinc, pH, total alkalinity (T-Alk), electrical conductivity, and sodium. The degree and rate of monthly change varied considerably between RCBs. Macronutrients generally increased at most nurseries in one to two months after fertilizer application particularly in 3 RCBs (MD21, VA11 and VA12), with levels of N and P forms exceeding preferred criteria for irrigation water by June and July in VA11 and VA12. Micronutrients fluctuated less, but did vary per RCB with the most monthly change occurring in MD21. Even though pH fluctuated, pH tended to remain alkaline or neutral to acidic respective of the RCB during the entire sample period. T-Alk tended to increase over the summer. EC primarily fluctuated in RCBs with high macronutrient levels. Although levels of N- and P-forms were mostly suitable by irrigation water criteria, they were frequently above U.S. Environmental Protection Agency nutrient criteria for promoting healthy water environments of lakes and reservoirs, and are discussed.

Specified Source(s) of Funding: USDA NIFA SCRI

3:30 PM – 3:45 PM
Limiting Phosphorus and Potassium Controls Plant Growth of Floriculture Species
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John Dole
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Brian Whipker
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An asterisk (*) following a name indicates the presenting author.
Greenhouse Rose Responses to Nitrogen
Confounded By Collateral Effects on Rootzone pH and Micronutrient Availability

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A study was established to re-evaluate the relationships of rose leaf nitrogen (N) status—expressed both on leaf weight and area basis—and flower productivity/quality in own-rooted and grafted (Peach Avalanche® on 'Natal Briar') rose plants. The plants were irrigated with six complete nutrient solutions (based on a modified 0.5x Hoagland solution) differing in total N concentration: 2, 4, 6, 8, 10, and 12 mM; tap water added an extra 1.5 mM of N to all treatments. Nitrogen was applied with an average 12% ammonium fraction, using sulfate salts as substitute for nitrate salts in the lower N treatments, thus producing iso-equivalent N to all treatments. Nitrogen was applied with an average 12% ammonium fraction, using sulfate salts as substitute for nitrate salts in the lower N treatments, thus producing iso-equivalent N to all treatments. Nitrogen was applied with an average 12% ammonium fraction, using sulfate salts as substitute for nitrate salts in the lower N treatments, thus producing iso-equivalent N to all treatments. Nitrogen was applied with an average 12% ammonium fraction, using sulfate salts as substitute for nitrate salts in the lower N treatments, thus producing iso-equivalent N to all treatments.

Concentrations of Mn, and Fe as well, provided significantly high
correlations with the observed flower yield and foliage quality responses. Evaluation of the applied nutrient solutions and drainage (leachate) solutions collected at several points through the study suggest that despite initial pH adjustments across all N solution treatments, nitrification activity increased with total applied N concentrations, leading to concomitant reductions in pH values. While the soil solution pH differences were within 1 pH unit across all treatments, the range in which it occurred (5.8–6.9) was deemed critical for a differential availability of micronutrients in solution, more acutely for the non-chelated Mn supply, despite increases in their application rate during the second half of the study. As this particular scenario is a first occurrence in our rose nutrition studies, a specific cultivar (varietal) response is strongly suspected to be in play as well.

Specified Source(s) of Funding: Floriculture and Nursery Research Initiative (USDA-ARS); Horticultural Research Institute; NJ Agricultural Experiment Station; Texas A&M AgriLife

3:45 PM – 4:00 PM

Comparison of Substrate Silicon Amendments for Greenhouse Sunflower Production

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Silicon (Si) is a plant-beneficial element that can alleviate the effects of abiotic and biotic stress. Substrate components, substrate amendments, liquid fertilization, and foliar sprays can supply supplemental Si to plants. Substrate amendments can provide extended release of Si throughout the production cycle, but information on incorporation rates and effects on plant growth are not well known. Our objective was to evaluate substrate amendments as potential sources of Si for production of ornamentals in soilless substrates. The base substrate was an 85 : 15 sphagnum peatmoss : perlite substrate. Amendments included parboiled rice hulls at 5%, 10%, or 20% (by volume); ground parboiled rice hulls at 5%, 10%, or 20% (by volume); rice hull biochar at 1.5%, 3%, or 6% (by volume); steel slag at 2.37, 4.75, or 7.12 kg·m⁻³ (PlantTuff); hydrous potassium silicate at 0.38, 0.76, or 1.14 kg·m⁻³ (AgSil); calcium silicate at 0.39, 0.78, or 1.17 kg·m⁻³ (wollastonite); a non-amended control; and a non-amended control fertilized with 2 mM potassium silicate at each irrigation. Lime was added (1.19 to 2.97 kg·m⁻³) as needed to adjust initial substrate pH of each treatment to 6.2–6.5. Four-week-old sunflower (Helianthus annuus L. ‘Pacino Gold’ seedlings were transplanted into 11.5-cm pots. They were arranged in a completely randomized design, with five pots per treatment, and grown for six weeks. Greenhouse conditions were 22 °C day/18 °C night, a 14-h photoperiod, and supplemental irradiance from high-pressure sodium lamps when ambient irradiance was less than 300 μmol·m⁻²·s⁻¹ photosynthetic photon flux density (PPFD). Plants were fertilized with 20N-4.4P-16.6K at a concentration of 150 mg·kg⁻¹ N at every irrigation. Plant growth and quality (height, width, relative chlorophyll content,
4:15 PM – 4:30 PM

**The Effect of Calcium Application Method to Increase Plant Resistance to Botrytis**

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Previous research has demonstrated that *Botrytis* infection of petunia flowers decreases when calcium levels increase in the petal tissue. The objective of this experiment was to determine the optimal method to deliver calcium to petunia flower petals. The two methods tested were: 1) supplying calcium in the fertigation solution, and 2) supplying calcium in spray applications using calcium chloride. A two-factor factorial design was used to test both methods. All nutrients in the fertigation treatments remained the same except for calcium, sodium and chloride. The fertigation treatment provided calcium concentrations of 0, 100, and 200 mg·L⁻¹ for 3 weeks prior to flower opening. The spray applications provided calcium concentrations of 0, 750, and 1500 mg·L⁻¹ once a week for 3 weeks. Growing medium, leaves, and flowers were analyzed for calcium content to determine the effect of application method and concentration on the tissue calcium concentrations. *Botrytis* efficacy trials determined which treatment method provided the most plant resistance to *Botrytis* infection upon inoculation. The results showed that increasing calcium concentration in the fertigation solution improved the calcium concentration in the leaves but not the flowers. Spray applications of calcium significantly increased the calcium concentration of the flower petals compared to the fertigation treatments and also had the lowest incidence of *Botrytis* infection. These results demonstrate the benefit of using calcium chloride spray applications to increase calcium content in reproductive tissue and increase petunia flower petal resistance to *Botrytis* infection.

*Specified Source(s) of Funding:* Floriculture Research Alliance, American Floral Endowment

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**Estimating Tissue Nitrogen (N) Content in Floriculture Crops Using Image Analysis**

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Krishna Nemali
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Tissue N content should be maintained at optimal level to achieve the maximum growth and good quality in floriculture crops. Laboratory analysis is the only direct method available to growers for accurate measurement of whole-plant N status. However, this method is expensive and time-consuming. Other indirect methods (chlorophyll meters and normalized difference vegetation index (NDVI) sensors), can only measure small leaf sections or contain background signal when measured on groups of plants, especially small plants. There is an urgent need to develop alternate techniques for easy, rapid, accurate and inexpensive measurement of tissue N content. Tissue N affects chlorophyll content of leaves, thereby red light absorption/reflectance in plants. Thus, measuring changes in red light absorption or reflectance can be used to indirectly measure changes in tissue N content. The purpose of the current study is to test the efficacy of camera based image analysis technique as an alternative to indirectly measure whole-plant N content. An experiment was setup in greenhouse maintained at 26/20 °C (day/night) temperature and daily light integral (DLI) of 10–20 mol·m⁻²·d⁻¹. Petunia (*Petunia × hortorum* L. ‘Hurrah Peppermint Stick mix’) and poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch ‘Maren’) plants were grown under five different fertilizer treatments with electrical conductivity (EC) of 0.75, 1.5, 2.0, 2.5, and 3.5 dS·m⁻¹ (74, 148, 198, 248, and 346 mg·L⁻¹ N) to generate a range of tissue N levels. A TopView imaging station with multi-spectral camera was used for capturing grayscale images at red (r, 630 nm) and near infrared (nir, 870 nm) wavebands. Each pixels on a grayscale image contain information on the extent of reflected light from plants. The grayscale images were analyzed using MultiSpec V2.0 image processing software to obtain mean gray or reflectance value (R625 and R870) of plant pixels in the image, from which an image derived reflectance ratio (R630/R870) was calculated. Tissue N content was measured at harvest using laboratory analysis. Results showed that tissue N content increased linearly with increasing fertilizer EC. A statistically significant inverse relationship was observed between tissue N content and R625/R870 in both species indicating that the ratio can be used to indirectly estimate whole-plant N content in poinsettia and petunia. We are currently developing cheap accessories for smartphones, which can aid in image capture, image processing, generation of reflectance ratios and estimation of tissue N based on algorithms for easy, rapid, accurate and inexpensive estimation of tissue N content in plants.

*Specified Source(s) of Funding:* The Fred C. Gloeckner Foundation
Effects of Phosphorus Nutrition on the Betacyanin Concentration and Foliar Coloration of Alternanthera Brasiliana

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Plants experiencing a phosphorus (P) deficiency commonly develop a red to purple coloration of the foliage. This pigmentation is typically attributed to foliar anthocyanins, and the relationship between P nutrition and anthocyanin accumulation is well known. Betacyanins are another red pigment produced in certain species that do not produce anthocyanins, but the relationship between P nutrition and betacyanin accumulation is not documented. We conducted this study to record the effects of P nutrition on the betacyanin concentration and subsequent foliar coloration of alternanthera [Alternanthera brasiliana (L.) Kuntze]. In an initial experiment, we grew ‘Purple Prince’ alternanthera with P concentrations of 0, 2.5, 5, 10, and 20 mg·L⁻¹ P. After four weeks, we restricted half of the plants from each non-zero concentration to 0 mg·L⁻¹ P, resulting in nine total treatments. In further experiments, we grew ‘Brazilian Red Hots’ and ‘Little Ruby’ alternanthera with the same treatments plus three additional fertilization treatments where plants initially grown with > 2.5 mg·L⁻¹ P were restricted to 2.5 mg·L⁻¹ P. Plants grown without P for the duration of the study were dark red or purple in coloration and had high concentrations of betacyanins. Alternanthera grown with high P concentrations for the duration of the study had the lowest betacyanin concentrations and exhibited less red and more green coloration as measured by a handheld colorimeter. This demonstrates that betacyanin accumulation is affected by P nutrition similarly to anthocyanin accumulation. Alternanthera grown with low or restricted P fertilization were stunted compared with those that were grown with sufficient P. Plants that were initially grown with 10 mg·L⁻¹ P but then restricted to 0 mg·L⁻¹ P also developed a dark red coloration and accumulated high concentrations of betacyanins, but were not stunted. This indicates that betacyanin accumulation may be enhanced without compromising growth. These findings may be used to improve fertilizer recommendations to enhance the foliar coloration and aesthetic appeal of horticultural species such as alternanthera.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation, USDA Floriculture and Nursery Research Initiative, American Floral Endowment Altman Family Scholarship, and The Garden Club of America.

Treatment of Calcium Chloride Enhances Water Deficit Stress Tolerance in Viola

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Water deficit stress during shipping and retailing can reduce postproduction shelf life and marketability of floriculture crops. To alleviate damage by water deficiency, plants need to limit transpirational water loss by inducing stomatal closure. Osmotic stress induces stomatal closure similar to water deficit stress in plants, and could be used as a convenient tool to enhance water deficit stress tolerance. The objective of this research was to investigate whether treatment with a high concentration of CaCl₂ could trigger a response to osmotic stress that induces stomatal closure and enhances water deficit stress tolerance in viola (Viola cornuta ‘Sorbet XP Yellow’). Leaf relative water content (RWC) and stomatal conductance were measured daily after CaCl₂ application. Preliminary studies that included various chemicals showed CaCl₂ was the most effective agent at delaying wilting under water deficit stress in viola. Compared to control, viola treated with CaCl₂ at 200 and 300 mM showed increased shelf life by 3.7 and 2.7 days, respectively. Leaf RWC of control plants was dramatically reduced 3 days after treatment and continued to decrease, while CaCl₂-treated plants maintained leaf RWC as high as that of well-watered plants until 6 days after treatment. On day 7, leaf RWC of plants treated with CaCl₂ was about twofold higher than that of control plants. Stomatal conductance was reduced by 73% to 86% within 4 hours after treatment with CaCl₂ compared to that of control plants. Our results indicated that osmotic stress induced by the treatment of high concentration of CaCl₂ might have caused stomatal closure, resulting in reduction of water loss and extension of shelf life under water deficit stress in viola. Pre-treatment of high concentration of chemicals such as fertilizers prior to shipping could enhance tolerance to water deficit stress in certain bedding plants.

Pomology I

Moderator: Esmaeil Fallahi
University of Idaho Parma Research & Extension Center, Parma, ID, USA

Transcriptomics Analysis of Spatial and Temporal Regulation of Apple Fruit Growth

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An asterisk (*) following a name indicates the presenting author.
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**Oral Presentations**

**S80**

**Bahar Fallahi**
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Partitioning in ‘Honey Crisp’ Apple, Influenced and Fluctuations in the Mineral Nutrient Fruit Quality at Harvest and After Storage

As early as cell production followed by post-mitotic cell expansion. Regulation of growth across the fruit tissues and during different stages of development is not well understood. To determine the dynamic gene expression networks regulating apple fruit growth, we performed transcriptome profiling of the cortex and pith tissues at different stages of development and in response to crop load reduction (thinning) in ‘Golden Delicious Smoothee’. Thinning was performed at 11 days after full bloom, and resulted in increased fruit size at harvest, primarily due to differences in the size of the cortex. The pith and cortex tissues were sampled for RNA-Seq analyses at eight days after thinning treatment (8 DAFT), 19 DAFT, and 47 DAFT, corresponding to the period of high cell production, transition from cell production to expansion, and high cell expansion, respectively. The average sequencing depth of all samples was around 20 million reads. Multidimensional scaling analyses indicated that the largest transcriptomic differences were between the earliest stage and the two later stages, suggesting distinct regulatory programs between early and later stages of fruit development. Within each stage, the cortex and pith tissues displayed major differences in gene expression, indicating tissue specific regulatory networks facilitating fruit growth and development. Relatively, lesser differential gene expression was noted in response to thinning. This was especially apparent at 47 DAFT where only a few genes were differentially expressed between these samples, suggesting that the transcriptome changes induced by thinning during early fruit development (19 DAFT) had diminished by later stages. A weighted gene co-expression network analysis (WGCNA) uncovered a network module significantly correlated with the pith/cortex area, fructose and glucose concentration. Several hub genes within the module were discovered that may contribute to differences in growth patterns within the cortex and pith tissues. Data from this study provide insights into the spatial and temporal mechanisms regulating fruit growth in apple.

Specified Source(s) of Funding: HATCH

**3:30 PM – 3:45 PM**

**Fruit Quality at Harvest and After Storage and Fluctuations in the Mineral Nutrient**

*Partitioning in ‘Honey Crisp’ Apple, Influenced by Thinning and Rootstock*

Esmaeil Fallahi*
University of Idaho Parma Research & Extension Center, Parma, ID, USA

Bahar Fallahi
University of Idaho Parma Research & Extension Center, Parma, ID, USA

Apple fruit consists of multiple tissues of distinct origins, primarily: the cortex derived from the floral cup, and the pith derived at least in part from the ovary. The cortex and the core tissues display differences in growth characteristics during fruit development. Temporally, fruit growth is achieved through an early phase of cell production followed by post-mitotic cell expansion. Regulation of growth across the fruit tissues and during different stages of development is not well understood.

To determine the dynamic gene expression networks regulating apple fruit growth, we performed transcriptome profiling of the cortex and pith tissues at different stages of development and in response to crop load reduction (thinning) in ‘Honey Crisp’ apple. Both early and late thinning of fruit down to one fruit per spur reduced fruit firmness but increased fruit size, and color compared to the lighter thinning levels. Trees receiving early thinning had less bitter pit than those with late fruit thinning. Thinning influenced mineral nutrient fluctuations in leaf and fruit. Trees on G.30 and V.1 rootstocks had larger fruits with lower firmness in 2016. Fruit from trees on G.202 had higher firmness in both 2016 and 2017. Fruit from trees on G.30 were largest in 2016 but smaller in 2017. Trees with G.30 had higher but those on G.202 had lower yield per tree than those on other rootstocks in 2016. Trees on M.26 EMLA had higher but those on G.202 had lower leaf N, Mg, Mn and fruit N, leading to better color in the scion fruit with G.202 in 2016. Trees on G.969 and G.202 had higher but those on G.30 and V.1 had lower fruit Ca in 2016. Trees on G.969 also had high leaf Ca in 2016. The magnetite of fruit Mg in trees on G.969 and G.202 were opposite to their fruit Ca. Although year-to-year yield variations may lead in to different results in some fruit attributes and mineral concentrations, some obvious consistent rootstock effects were observed in both years. For successful production of high quality ‘Honey Crisp’ apple, the combined impact of rootstock and thinning on tree growth, yield, fruit quality and mineral nutrient concentrations should be considered, and we are closer to achieve this combination in our study.

Specified Source(s) of Funding: SCRI Block Grant Idaho Department of Agriculture

**3:45 PM – 4:00 PM**

**Strategies to Improve Defoliation of Apple Nursery Trees in the Eastern United States**

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The use of size-controlling rootstocks and crop load adjustment are routine practices in the high-density apple orchards. The influence of five thinning levels and five rootstocks on yield, fruit quality, and mineral fluctuations in leaf and fruit tissues were studied in ‘Honey Crisp’ apple. Both early and late thinning of fruit down to one fruit per spur reduced fruit firmness but increased fruit size, and color compared to the lighter thinning levels. Trees receiving early thinning had less bitter pit than those with late fruit thinning. Thinning influenced mineral nutrient fluctuations in leaf and fruit. Trees on G.30 and V.1 rootstocks had larger fruits with lower firmness in 2016. Fruit from trees on G.202 had higher firmness in both 2016 and 2017. Fruit from trees on G.30 were largest in 2016 but smaller in 2017. Trees with G.30 had higher but those on G.202 had lower yield per tree than those on other rootstocks in 2016. Trees on M.26 EMLA had higher but those on G.202 had lower leaf N, Mg, Mn and fruit N, leading to better color in the scion fruit with G.202 in 2016. Trees on G.969 and G.202 had higher but those on G.30 and V.1 had lower fruit Ca in 2016. Trees on G.969 also had high leaf Ca in 2016. The magnetite of fruit Mg in trees on G.969 and G.202 were opposite to their fruit Ca. Although year-to-year yield variations may lead in to different results in some fruit attributes and mineral concentrations, some obvious consistent rootstock effects were observed in both years. For successful production of high quality ‘Honey Crisp’ apple, the combined impact of rootstock and thinning on tree growth, yield, fruit quality and mineral nutrient concentrations should be considered, and we are closer to achieve this combination in our study.

Specified Source(s) of Funding: SCRI Block Grant Idaho Department of Agriculture
chemicals or chemical combinations that would provide the most effective leaf senescence and defoliation of apple nursery trees, a two-year study was conducted at an on-farm nursery located in the Western New York. Four chemicals and their combinations were applied to nursery trees of ‘Gala’/B.9 and ‘SweeTango’/B9: copper, urea, a commercial formulation of abscisic acid – ABA (Protone®, Valent BioSciences, Libertyville, IL) and organosilicone surfactant (Silwet® L-77; Helena Chemical Co.), in the fall of 2016 and 2017. Rates and timing of application were tested. Timing of application was set according to a projected date determined by the nurseryman of when trees would be harvested for subsequent cold storage. Percentage of defoliation (%) was assessed weekly after treatment application in both years. In the following spring of each year trees were re-assessed for any type of bud injury that the products applied could have caused and for initial growth. Temperature was one of the major driving factors that influenced the efficacy of the defoliants. Warm temperatures (above 55 °F) during and after spray application (at least 3–4 days) are required for better defoliation. In both years, the maximum defoliation of some treatments was observed in one to three weeks after application. In some cases, a frost event is desired for previously treated trees to complete defoliation.

ABA has shown great efficacy in promoting leaf senescence and defoliation. However, previous studies have shown that the application of ABA itself is not sufficient for full defoliation of young trees. Therefore, the addition of quelated copper, Silwet or urea in the ABA tank provided substantial increase of defoliation. Based on the two-year experiment, we have found several promising alternatives, however, the best option that has shown the most consistent results over the two years was, so far, the combination of ABA + CuEDTA + Silwet. Some choices will depend on how much defoliation is desired (50 to 100% defoliation) and the additional benefits the combination may provide. Cost-benefit will be probably favorable.

Specified Source(s) of Funding: International Fruit Tree Association—IFTA

4:00 PM – 4:15 PM

Self-Compatibility and Comparison of Its Impact on Fruit and Seed Set in the North American Pawpaw

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Pawpaw (Asimina triloba), America’s forgotten tree fruit, is emerging as an alternative high-value niche crop for small farms in Kentucky. Some literature states that pawpaw is a cross-pollinated crop; however, there is evidence of self-compatibility in some varieties such as ‘Sunflower’. The objective of this study was to determine if the pawpaw cultivars Sunflower and Susquehanna display self-compatibility and if this impacts fruit set. Two pawpaw cultivars, ‘Sunflower’ and ‘Susquehanna’, were examined in this study at the Kentucky State University Harold R. Benson Research and Demonstration Farm. In total 1000 crosses, including 250 self and cross pollinations for each variety, were carried out with open flowers in April, 2016 and 2017; competing flowers were removed after pollination. In 2016, the number of fruit clusters and fruit per cluster were recorded on three dates: 24 May, 22 July, and 22 Aug. Similarly in 2017, the data were recorded on: 31 May, 13 June, and 21 Aug. The seeds from each treatment were extracted from the fruit and stratified (4 °C) in wet peat moss for at least 110 days. The seeds from 2016, 20 of each self or cross, were then germinated in pots in a greenhouse. Young leaves of parent material and the newly germinated offspring were collected for DNA extraction. Primers for three pawpaw simple sequence repeat (SSR) for the loci Pp-B3, Pp-B103, and Pp-G124 with unique fingerprint patterns for each variety were selected for parentage confirmation. This is the first study to report DNA evidence supporting self-compatibility in pawpaw. The DNA fingerprinting results confirmed the occurrence of some self-fruit set in both ‘Sunflower’ and ‘Susquehanna’. Surprisingly, ‘Susquehanna’ was found to exhibit greater self-compatibility compared to ‘Sunflower’ based on the percentage of self-pollinated offspring. Although both cultivars served as pollinizers to each other, the ultimate fruit set seemed to have a direct relationship to the genetic yield potential of the maternal tree.

Specified Source(s) of Funding: USDA Evans Allen Research Grant

4:15 PM – 4:30 PM

Nutrient Storage in Dormant Peach Trees Following Variable Fall Climate

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Variability in autumn climate resulting in warmer and drier conditions can delay leaf senescence in deciduous fruit trees. As leaves remain for an extended season, trees may allow additional nutrient mobilization to the reserves (stem and roots), which can impact nutrient uptake in the following spring. In this study, we evaluated the nutritional responses of two-year-old peach trees to fall temperatures and soil moisture on two cultivars (‘Scarletprince’ and ‘Autumnprince’ both on Guardian™ rootstock). We applied four treatments to the two cultivars: 1) well-watered trees (100% ETc needs) grown under ambient outdoor temperatures; 2) water deficient trees (50% ETc needs) grown under ambient outdoor temperatures; 3) well-watered trees grown in a greenhouse; and 4) water deficient trees in a greenhouse. Average temperature in the greenhouse was 5 °C warmer than ambient outdoor temperature. Trees inside the greenhouse had delayed senescence and there were no significant
differences in total leaf number or leaf area between the trees in the greenhouse and outdoor environments prior to senescence. We measured nutrient concentrations in leaves during the fall and in the reserve tissues (new shoots, one-year old shoots, stem above and below the graft union, lignified roots, and fibrous roots) during the winter to assess mobilization. Across fall sampling, leaf nitrogen and phosphorus concentrations were significantly lower inside the greenhouse while potassium was significantly higher in trees outside. Across all tissue locations during winter, nitrogen and potassium concentrations were significantly higher in greenhouse trees than in trees outside, while both nitrogen and phosphorus were significantly higher in water deficient trees than in well-watered trees. Significantly higher levels of potassium were also found in ‘Autumnprince’ compared to ‘Scarletprince’ across tissue locations during the winter. Provided consistent differences between treatments regarding remobilized nutrients, this study could provide a model for the larger climate change discussion within deciduous fruit tree cultivation and provide a platform for further research to optimize management practices encouraging environmental and orchard sustainability.

4:30 PM – 4:45 PM

**The Relationship between Peach Fruit Weight, Crop Density and Early Season Temperature**

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A multi-location study was conducted over four years to evaluate the effect of crop density (CD) and early-season temperatures, alone and in combination, on fruit weight (FW) at harvest. ‘Redhaven’ and ‘Cresthaven’ peach trees growing at five sites were hand-thinned each of four years to provide a range of CDs. For each site, cumulative growing degree days were calculated from minimum and maximum daily temperatures for the first 30 days after 50% full bloom using 4 °C as the base temperature (CGDD\(_{50}\)). The relationships between average fruit weight (FW) and CD and CGDD30 were fairly variable, but FW was generally negatively related to both CD and CGDD\(_{50}\). Variability in the data likely resulted from differences in orchard practices and environmental conditions at the different sites. The interaction of CD and CGDD\(_{50}\) was rarely significant at an individual site, indicating that the two factors are independent and have an additive effect on FW and days from bloom to harvest.

**Specified Source(s) of Funding:** NIFA and USDA and Agr. Expt. Stations in PA, NY, MD, SC, and KY

4:45 PM – 5:00 PM

**Fertilize Less and Irrigate: Improving the Recommendations for Young Peach Trees in the Southeastern United States**

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Drought has been common in the southeastern United States in the past years, affecting peach production. Traditionally, young peach trees (one- to three-year-old) are not irrigated until the third year and rely on rain as water source. There is growing interest in irrigating young plants; however, no scientific guidelines are available for the region. Similarly, current fertilizer recommendations for young peach plants are outdated and/or based on studies performed in Mediterranean regions or California and may not be applicable to the southeastern United States. Improvement of the irrigation and fertilization recommendations is paramount and the objective of this research. ‘Julyprince’ plants grafted onto ‘Guardian’ rootstock were planted in 2015, at a density of 358 plants per hectare. Two irrigation systems (drip and micro-sprinkler), two irrigation rates (irrigated and non-irrigated), and four fertilizer rates (16, 33, 65, and 129 kg of N per hectare for one-year-old plants; and 23, 48, 95, and 191 kg of N per hectare for two-year-old plants) were tested. A network of sensors and nodes controlled the irrigation and maintained the soil volumetric water content (VWC) above an established threshold (varied from 15 to 25% of VWC). Granular fertilizer was hand-applied following current recommendations: one application of 10.0N–4.4P–8.3K in March and 2 applications of 15.5N-0P-0K, in May and July. Irrigated plants grew more than non-irrigated plants, with trunk cross-sectional area (TCSA) and canopy volume ~1.5X and ~1.7X greater, respectively, for both years. Fertilizer rates did not affect TCSA and canopy volume if plants were drip irrigated; however, higher fertilizer rates induced greater TCSA and canopy volume when micro-sprinkler irrigated, in general. Irrigation alleviated drought stress in 2016, increasing water potential and photosynthesis by ~0.6X and ~1.8X, respectively, for both years. However, no significant physiological responses were found in 2017, likely because it rained more than in 2016. The negative effects of the lack of precipitation and irrigation in 2016 carried over to 2017: the commercial yield of non-irrigated plants was ~20% lower when compared to irrigated plants. The fertilizer rates did not induce major differences for water potential, photosynthesis, and commercial yield. Compared to micro-sprinklers, drip irrigation
Increased stem water potential and photosynthesis in 2016, and commercial yield in 2017, while applying ~36% less water. In conclusion, drip irrigation was beneficial to young peach trees’ growth and fruit production; and fertilization can be adjusted/cutback by ~50% to reduce the environmental impacts and increase growers’ profit.

Specified Source(s) of Funding: Peach Commodity Commission Grant

5:00 PM – 5:15 PM

Impact of Nitrogen Fertilization on Apple Tree Growth, Fruit Development, and Cider Fermentation Kinetics

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Nitrogen fertilization is a little studied area of hard cider apple (Malus ×domestica Borkh.) production that potentially impacts tree growth, yield, fruit polyphenol concentration, yeast assimilable nitrogen in juice, and fermentation kinetics. In Spring 2016, a multi-year nitrogen fertilization study was started on two-year-old ‘Golden Russet’ and ‘Medaille d’Or’ tall spindle trees on G.30 rootstock in Ithaca, NY. Low (28 kg·ha⁻¹ N), medium (56 kg·ha⁻¹ N), and high (112 kg·ha⁻¹ N) nitrogen fertilizer treatments, plus an unfertilized control, were implemented by applying calcium nitrate granular fertilizer each spring. Greater nitrogen fertilizer rates resulted in increased tree size, as measured by trunk cross sectional area (TCSA) and central leader growth for both cultivars. In 2016, the low, medium, and high treatments had 28%, 25%, and 26% greater TCSAs than the control, respectively, and leaders were 36%, 46%, and 31%, longer than the control, respectively. In 2017, the high nitrogen fertilizer treatment increased TCSA by 66% relative to the control, but no other differences in tree growth were found for either cultivar. No differences in leaf nitrogen content were found among treatments for either cultivar in 2016 or 2017. Nitrogen fertilization advanced fruit maturity during the 2017 harvest. When data for both cultivars were analyzed in a single statistical model, fruit from the medium and high nitrogen treatments had an average of 0.5 and 0.8 greater starch index measurements than the control. Fruit from the high nitrogen treatment had 15% lower firmness than the control, and the medium and high nitrogen treatments had 28% and 14% lower deltal absorbance reading (chlorophyll content). No differences in juice polyphenol content were found in 2017, as measured by the Folin Ciocalteu assay. ‘Golden Russet’ juice from the high nitrogen treatment had 43% greater yeast assimilable nitrogen than the control. During fermentation of the ‘Golden Russet’ juice, the unfertilized control produced more hydrogen sulfide (a negative attribute) than fermentations from the low and high treatment fruit. This preliminary data suggests that nitrogen fertilization in the orchard impacts tree growth, fruit quality, and fermentation kinetics. However, additional years of data are needed to determine the consistency of these results.

Specified Source(s) of Funding: United States Association of Cider Makers

3:15 PM – 3:30 PM

Quantification of Root Growth of Transplants By Two-dimensional or Three Dimensional Root Scans in Propagation Substrates

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Digital scanning of roots using two-dimensional (2D) scanners or three-dimensional (3D) X-ray computed tomography (CT) are established research techniques. However, CT methodology is lacking in the wide range of substrates used in propagation. The objective was to quantify root growth by 2D or 3D scans for peat, rockwool, and phenolic foam (Oasis™) during mist propagation of Euphorbia pulcherrima ‘Prestige Red’ (poinsettia). The experimental design was a randomized block design with two blocks (growth chambers) and two replicate substrate moisture levels (capillary mats) per block. Unrooted cuttings were grown at three constant moisture levels. Three cuttings per treatment combination were harvested on day 14 of propagation. In one experiment, poinsettia were grown in peat (55-mL volume cell) held constant at 53, 58, or 63% volumetric water content (mL water/mL volume). Washed roots were scanned with an image scanner at 800 dpi and analyzed for total root length, surface area, and volume using WinRHIZOTM. Root growth using 2D imaging did not differ between moisture levels, and averaged 46.3-cm in total length, 13.8-cm² surface area, and 0.34-cm³ volume. In a second experiment, poinsettia were propagated in rockwool or foam. The substrate moisture levels were 11, 19, or 53% volumetric water content for rockwool (45-mL volume) and 18, 34, or 89% for foam (29.7-mL volume). Plants were scanned using nano-CT at 49.8 µm voxel resolution, 1200 images, and a 20-minute run time. Image segmentation of roots was achieved by drying the substrate down. Root growth was quantified by measuring total surface area, volume, and root count. In rockwool, the high moisture level resulted in a significant increase (P = 0.05) in root growth resulting in 760-mm² surface area, 153-mm³ volume, and 19 roots per cutting, relative to moisture levels. Contrast, in foam root growth was similar at 396-mm² surface area, 75-mm³ volume, and 14 roots per cutting across moisture levels. Root growth was also quantified

An asterisk (*) following a name indicates the presenting author.
by spacial distribution through image segmentation at 0.5-cm increments from the base of the stem to 2.0-cm depth in plug cells. Root scans by 2D quantified total root growth variables in substrates where roots could be washed. Imaging by CT scans preserves root system architecture in opaque growing media at high resolution and can be quantified for total root growth as well as root spacial distribution.

3:30 PM – 3:45 PM

Developing a Micropropagation Protocol for Abelia ‘Raspberry Profusion’

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Abelia is a genus of flowering woody shrubs with high ornamental and landscape potential. Among the cultivars commercially available A. ‘Raspberry Profusion’, a hybrid between A. ‘Edward Goucher’ × A. chinensis, stands out for its superior ornamental characteristics of rapid growth, drought tolerance, dark green glossy leaves, long flowering period, unique pink-red flowers, and pink sepals that remain in the plant during fall. Even though A. ‘Raspberry Profusion’ roots successfully from shoot cuttings, the propagation rate is limiting commercial production. A more efficient and faster protocol is needed. In this study we report the development of an in vitro micropropagation protocol. One node microcuttings from greenhouse-grown plants of two genotypes, A. ‘Francis Mason’ (as a control) (FM) and A. ‘Raspberry Profusion’ (RP), were cultured on Murashige and Skoog (MS) medium with vitamins or Woody Plant Medium (WPM) with vitamins both supplemented with 30 g·L⁻¹ sucrose, 8 g·L⁻¹ agar, pH adjusted to 5.9 and either 1 or 2 mg·L⁻¹ of 6-Benzylaminopurine (BA). Genotype and type of media had a significant effect on the number of shoots and nodes/shoot obtained in vitro after 4 weeks. FM produced more shoots on WPM (1.6 shoots and 3.2 nodes/shoot) than MS (1 shoot and 1.5 nodes/shoot), but no significant differences were observed between RP on WPM (0.7 shoots and 1.2 nodes/shoot) and RP on MS (0.9 shoots and 1.2 nodes/shoot). The effect of the origin of the explant was tested on RP. One node microcuttings from greenhouse or field-grown plants were cultured on WPM supplemented with 30 g·L⁻¹ sucrose, 8 g·L⁻¹ agar, pH adjusted to 5.9 and either 1 or 2 mg·L⁻¹ of BA. After 4 weeks of culture, BA had no significant difference in the number of shoots and nodes/shoot obtained in vitro; however, the field-grown explants performed significantly better (1.2 shoots and 2.2 nodes/shoot) than the greenhouse explants (0.2 shoots and 0.2 nodes/shoot). The effect of type of cytokinin was also tested using 1 mg·L⁻¹ of Thidiazuron (TDZ) or Kinetin (Kn) on FM and RP cultured on WPM. Type of cytokinin and genotype had significant effects on the number of shoots produced in vitro after 4 weeks. Best overall treatment was RP with TDZ producing an average of 3 shoots, FM only produced 1.4 nodes with TDZ. RP with KN produced 0 shoots and FM with KN produced 0.3 shoots.

3:45 PM – 4:00 PM

Hazelnut (Corylus L.) Propagation Techniques Used in Breeding, Cultivar Increase, and Orchard Establishment

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The OSU breeding program routinely uses tie-off layerage (stooling with shoot girdling) to clonally propagate hazelnut trees for yield trials and field exposure to eastern filbert blight (EFB) for disease susceptibility screening. For greenhouse EFB inoculations, trees are grafted in a heated greenhouse to promote callusing at the graft union. A hot-callusing pipe can be used for bench grafting in lieu of a greenhouse, and is suitable for many other species where dormant season open-field grafting is unsuccessful. Grafting also allows establishment of new orchards on clonal rootstocks that produce few suckers. Field grafting with a high success rate is possible if it is delayed until late spring, using scions collected in mid-winter and stored at –1 °C. Micropropagation is now used for rapid increase of new cultivars from the breeding program for commercial orchard planting and establishment of layering beds. Propagation by softwood cuttings from suckers and side branches on container-grown micropropagated trees is also successful in mid- to late- spring. Specified Source(s) of Funding: Oregon Hazelnut Commission

4:00 PM – 4:15 PM

Immature Embryo Germination—A Key Step to Speed up Woody Plant Breeding

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Woody plant breeding is a long-term commitment and a breeding cycle usually takes 5–30 years. Cross incompatibility (late abortion) and seed germination are challenging and time-consuming. To speed up woody plant breeding cycles, immature embryo germination in vitro were investigated and reviewed. To avoid embryo abortion and pest and disease contamination, immature embryos should be excised from the mother plants as soon as they are visible and could be removed from the fruits. After fruit maturation, it is hard to dissect embryos and prepare sterilized explants for culture. Timing to collect immature embryos should be investigated bi-weekly or monthly. Majority of immature embryos should be placed in dark conditions for the first two weeks for initiation of germination. Quarter strength of Murashige and Skoog (MS) medium should be explored for the initial germination and other media such as WPM with extra sugar could work as well. Each germinated micro-seeding is a clone and we can regenerate it through micro-cuttings and/or somatic embryogenesis. Woody horticultural plants (Ilex crenata and Kalmia latifolia as examples) with successful immature embryo germination

An asterisk (*) following a name indicates the presenting author.
(embryo rescue) had been reviewed and summarized. Successful immature embryo germination should be able to avoid late embryo developmental abortion and yield cross breeding seedlings at the same growing season for woody plants, instead of additional 1–3 years for seed harvesting and germination. The procedures for immature embryo germination were technically challenging, but significantly speeded up woody plant breeding cycles.

4:15 PM – 4:30 PM

**Impact of Irradiance and Carbon Dioxide Concentration on Photosynthetic Rate of Five Ornamental Plant Species/Hybrids Grown in Tissue Culture Containers**

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Separate plastic tissue culture containers containing four ornamental plant species/hybrids (Anigozanthus flavidus, Aloe vera, Dionea muscipula, a Trichopilia hybrid, and a Phalaenopsis hybrid) that differed in perceived irradiance requirements were acquired from two commercial laboratories. Holes were drilled in the sides of the containers and a plastic tube and rubber stopper were inserted in each (a hole was drilled in the stopper to insert the plastic tube) to create an air-tight flow-through system compatible with a portable photosynthesis meter (LiCor LI-6400) to determine initial container carbon dioxide concentration (CO₂) under typical lab conditions (50 µmol·m⁻²·s⁻¹, 23 °C). Following this initial CO₂ measurement, photosynthetic CO₂-response curves were developed for the change in CO₂ entering versus exiting each chamber (approximates photosynthesis) as CO₂ levels increased from 25 up to 1300 ppm (species specific) while maintaining irradiance at 50 µmol·m⁻²·s⁻¹. Photosynthetic irradiance-response curves (0 up to 1300 µmol·m⁻²·s⁻¹, species specific) were then determined (based on changes in CO₂ concentration entering versus exiting containers) at the initial CO₂ levels measured for each flask (~25–275 ppm for each species) to ascertain the impact of increasing irradiance under lab conditions. Lastly, both irradiance and CO₂ were simultaneously increased from lab conditions to the irradiance and CO₂ saturation levels determined above to establish the maximum potential increase in photosynthesis of each species. Implications of this work in tissue culture production when considering increasing irradiance and/or injecting CO₂ will be discussed.

**Specified Source(s) of Funding:** USDA-ARS; FRA; Minnesota Agriculture Experiment Station

4:30 PM – 4:45 PM


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Robert Geneve
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Frederick Davies
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The world’s standard for plant propagation and horticulture since 1959, Hartmann and Kester’s Plant Propagation: Principles and Practices just unveiled its 9th edition in 2018. Twenty one chapters are organized into five sections discussing: 1) general aspects of plant propagation, 2) seed propagation, 3) vegetative propagation, 4) tissue culture propagation, and 5) propagation of selected plants. Supplemental to the text are instructional resources that include captioned PowerPoint slides for each of the 679 Figures as well as a test bank and key of 422 exam questions. These are comprised of short answer, fill in the blank, multiple choice, and true/false and can be downloaded from the Pearson website with a unique access code. Separately, online resources have been prepared to complement important concepts in the text and facilitate learning. These include 1) storyline interactions for each chapter, 2) animation of a typical angiosperm lifecycle, 3) a web application for nearly 500 glossary terms with images/video, 4) videos of propagation practices, and 5) guest lectures of experts in the field.

4:45 PM – 5:00 PM

**Seed Dormancy and Germination in the Iris Raevigata fisch. (Iridaceae)**

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*Iris laevigata* Fisch., which belongs to the Iridaceae, is a perennial plant native to Korea, China, Japan, and Russia, grows in the mud of a pond, stream, or river bank. Purple flowers, which are about 12 cm in diameter, are highly valued in May and June. However, it is now designated as a “Data Deficient” (DD) grade (Korea Forest Service) because it does not have many natural sites known for its reckless development and damage to its natural habitats. Preservation and reproduction and further development into coronary plants require the development of reproductive methods. This study was carried out to determine the dormancy type of *I. laevigata* seeds and to establish the germination conditions to restore the native habitat of the *I. laevigata* and to preserve its status outside of its current habitat. Temperature requirements...
for embryo growth and germination were determined by incubating seeds under controlled laboratory conditions. The seeds had underdeveloped embryos, which had grown to about 55% of those of fully matured seed before germination. When tested at the time of dispersal, seeds did not germinate during 16 weeks of without chilling treatment. Therefore, the seed dormancy type for *L. laevigata* was morphophysiological. In the controlled laboratory experiment, after cold stratification at 5 °C for 0, 4, 8, or 12 weeks, the seeds germinated to 0, 11.7, 43.4, or 51.7%, respectively, after two weeks of incubation at 25 °C. After warm (25 °C, 8 weeks) followed by cold stratification for 0, 4, 8, or 12 weeks, the seeds germinated to 0, 51.7, 85.0, or 88.3%, respectively, after two weeks of incubation at 25 °C. Additionally, GA$_3$ treatment did not overcome the dormancy. Therefore, the seeds expressed deep simple morphophysiological dormancy (MPD). The results of this research were introduced at KSHS 2017 Annual Autumn Conference through poster presentation.

5:00 PM – 5:15 PM

**Seed Dormancy and Germination of Coreanomecon Hylomeconoides Nakai (Papaveraceae), a New Ornamental Plant in Korea**

Seung Youn Lee*

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Korea National Arboretum has recently started the project ‘Wild Flowers’ for the commercialization of wild flowers native to Korea. In this project, we have selected 30 herbaceous (*Euphorbia jolkii*, *Minuartia laricina*, *Veronica kiusiana* var. *diamantiaca*, *V. pusanensis*, *Coreanomecon hylomeconoides*, and etc.) and 6 woody species (*Hydrangea serrata* f. *fertilis*, *Exochorda serratifolia*, *Lonicera insularis*, and etc.) as new ornamental crops. The project consists of four contents: 1) floral market survey, propagation, and cultivation physiology including flowering control, 2) ornamental plants breeding, 3) model garden development, 4) finding traditional knowledge with the potential plants. Among the potential plants, *Coreanomecon hylomeconoides* (Papaveraceae) is a perennial herb and is endemic to Korea. This species has great potential as garden and landscape plant because it has long flowering period from May to September in Korea. However, *C. hylomeconoides* has seed dormancy at dispersal, and thus seed propagation is difficult. Ripe seeds were collected between 16–19 June. The seeds were sown in field soil in an experimental garden. We investigated the phenology of embryo growth, germination, and seedling emergence in the natural environment. Temperature requirements for embryo growth and germination were also determined by incubating seeds under controlled laboratory conditions. The effect of GA$_3$ concentrations (0, 10, 100, or 1000 mg·L$^{-1}$) on dormancy breaking was also tested to characterize the type of seed dormancy. Seeds had underdeveloped embryos, which was about 13% in length of fully matured seed. When tested at the time of dispersal, seeds did not germinate during four weeks of incubation at 25 to 15 °C. Thus, *C. hylomeconoides* seed has morphophysiological dormancy. In natural conditions, embryos grew at temperature between 5 and 15 °C (average 10 °C) on late October. However, the seed did not germinate immediately after embryo elongation. After cold temperature season during winter, the seed germinated to about 80% when the temperature increased to 0 to 5 °C. More than 80% of seedlings emerged when the temperature increased to about 10 °C in the natural environment. None of the seeds germinated at 25 to 15 °C during 40 weeks of incubation whereas the seeds germinated to about 40% when the seeds were subjected to the temperature sequence (25/15 °C → 20/10 °C → 15/6 °C → 5 °C → 15/6 °C → 20/10 °C). The GA$_3$ treatment increased embryo growth in the seeds, but less than 20% of them germinated at 25/15 °C with 1000 mg·L$^{-1}$. Based on these results, seed dormancy of *C. hylomeconoides* can be broken through warm followed by cold temperature sequence and classified as having deep simple morphophysiological dormancy (MPD).

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**Wednesday, August 1, 2018**

**Weed Control and Pest Management 1**

*Moderator: Mohammad Babadoost*

University of Illinois, Dept. Crop Sci., Urbana, IL, USA

8:00 AM – 8:15 AM

**Rapid imaging and cell counting of Bacillus Atrophaeus cultures in an automated manner using the InCellis® Smart Cell Imaging System**

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Sophie Dubacq

Bertin Instruments, Montigny le Bretonneux, France

Olivier Varet

Bertin Instruments, Montigny le Bretonneux, France

In cell biology and microbiology related studies, accuracy and efficiency in cell culture quality checks are crucial in order to avoid any potential complications in downstream analysis. Usually, different cell parameters such as cell counting, cell size measurement and cell culture confluency are assessed and estimated visually in a subjective way. However, visual assessments are unreliable, time consuming and often yielding inaccurate results which lead to incorrect conclusions and incorrect recommendations. In this study, a novel imaging system was evaluated using *Bacillus atrophaeus* cultures. Bacterial strains were used...
to accurately count cell number in an automated manner using embedded applications on the InCellis® Smart Cell Imaging System. A series of images of the cultures were taken in phase contrast mode using 40x objective at different cell dilutions (2 × 10^6, 4 × 10^6, 8 × 10^5). A total of five images of the bacterial culture were taken at different field of view using 40x magnification on InCellis®, and were further used to estimate a total number of bacterial cells in the cell counting slide (18mm × 10mm). The results demonstrated that the system is capable of count total number of cells in a rapid manner and is a useful tool for cell density calculation. The cell counting application ensured a rapid and efficient quality control of the cell cultures and allowed to obtain robust results with a stain-free method in comparison to the standard method. The automated applications not only provide consistent results but also significantly reduce the hands-on time for all cell-based assays.

8:15 AM – 8:30 AM
Managing Phytophthora Blight, Caused By Phytophthora Capsici, in Cucurbits
Mohammad Babadoost*  
University of Illinois, Dept. Crop Science, Urbana, IL, USA
Phytophthora blight, caused by the oomycete Phytophthora capsici, is one of the most important diseases of cucurbits worldwide, causing up to 100% crop losses. Major symptoms caused by P. capsici on cucurbits are seedling death, foliar blight, and fruit rot. P. capsici also infects more than 40 species in 15 plant families. There is no cucurbit cultivar with measurable resistance against Phytophthora blight available. Cultural practices and chemical use are the options for management of this disease in cucurbit fields. We developed effective strategies for managing Phytophthora blight of cucurbits by integrating cropping rotations, seed treatment, field scouting, and fungicide sprays. Cropping rotations of three years with nonhost crops was established after the host range and survival of P. capsici in soil were determined. Seed treatment with mefenoxam (0.42 mL Apron XL®/kg of seed) and spray applications of effective fungicides reduced yield losses from up to 100% to less than 10% in commercial fields. In the past 15 years, more than 10 new fungicides with different modes of action were registered for management of Phytophthora blight of cucurbits. Field scouting and removing/disking infected plants in small areas in the early disease development stage helped to delay the spread of the disease in the fields. Plant should not be irrigated from pounds that contain water drained from infested fields.

8:30 AM – 8:45 AM
Evaluation of Weed Management Techniques in East Coast Broccoli Production
Matthew Cutulle*  
Clemson University, Charleston, USA
Mark Farnham  
USDA-ARS, Charleston, SC, USA
The majority of the broccoli grown in the United States is located in California and Arizona. However, USDA-SCRI-funded grants have focused on establishing an east coast broccoli industry. One of the reasons it can be more difficult to grow broccoli on the east coast from a weed management perspective is higher rainfall, which can lead to greater and more consistent weed pressure as well difficulties utilizing a soil cultivator due to high soil moisture. Thus a better understanding regarding weed control strategies is needed for Research was conducted at the United States Vegetable lab in Charleston, SC, to evaluate the impact of herbicides and cultivation on weed control and crop health. The experiment was conducted as a randomized complete block with three replications and 10 treatments. Two Broccoli cultivars, Lieutenant and Emerald Crown were transplanted to the field on 22 Sept. 2017. The treatments were structured as a factorial with five herbicide treatments (pyroxasulfone, oxyfluorfen, S-metolachlor, napropamide or no herbicide) × two cultivation treatments (Cultivated or Not Cultivated). The herbicides were applied to the soil three days prior to transplanting. Cultivation treatments were applied three weeks after transplanting. Weed species in the plots included yellow nutsedge, carpetweed, purslane, and yellow foxtail. Twelve weeks after transplanting the best treatments for controlling these weeds were oxyfluorfen with Cultivation and S-metolachlor with cultivation, which provided 85 and 88%, respectively. No injury was observed from any of the treatments.

8:45 AM – 9:00 AM
MS79 Is a Microbially Derived Selective Cellulose Biosynthesis Inhibitor
Mohammad Radhi Alsabri*  
University of Kentucky, Lexington, KY, USA
Herbicides are used to control weeds in agricultural systems and to beneficially shift the competition between crops and weeds. Despite their importance, few new mechanisms of action have been elucidated in recent decades. Here, we describe the identification of a bio-derived herbicidal mixture from an endophytic bacterium named MS79. The MS79 strain was isolated from switchgrass tissue. A preparation of concentrated cellular material disturbs the biosynthesis cellulose in plants exposed to the mixture. Accordingly, isolation with XAD18 resin to purify metabolites results in a herbicidal mixture with similar activity against cellulose biosynthesis. The application of the MS79 to a range of plant genera suggests that it caused substantial reduction in cellulose content Sorghum bicolor L and other monocotyledonous plants. However, Solanaceous broad leaf crops, for instance Nicotiana tobaccum and Solanum lycopersicum, are less sensitive. The genome of MS79 was sequenced, revealing the presence of plant-microbe association genes and several genes encoding proteins capable of binding to or degrad-
ing plant cell wall carbohydrates. Thus, we propose that MS79 is a Class L herbicide, with specificity toward grass control in Solanaceous crops.

**Growth Chambers and Controlled Environments 2**

*Moderator: Shane Palmer*
University of Georgia, Athens, GA, USA

8:00 AM – 8:15 AM

**Photoperiodic Effect on Growth and Development of Basil Species and Cultivars**

Charlie Garcia*
Michigan State University, East Lansing, USA

Roberto G. Lopez
Michigan State University, East Lansing, MI, USA

Retailers and consumers generally do not desire or accept potted or fresh cut culinary herbs with flowers as vegetative growth can be negatively impacted. This in turn creates problems for greenhouse growers who often struggle to keep basil (*Ocimum*) vegetative. Limited photoperiodic studies have been conducted on common herbs such as basil to determine how changes in day length can influence flowering. The objective of this study was to quantify how photoperiod influences growth and development of 4 basil species and 11 cultivars. Seeds of ‘Genovese Basil’, ‘Sweet Thai’, ‘Cinnamon Basil’, ‘Red Ruben’, ‘Sweet Dani Lemon’, ‘Purple Ruffles’, and ‘Nufar OG’ (*Ocimum basilicum*), ‘Lime Basil’ (*Ocimum xcitriodorum*), ‘Holy Basil’ (*Ocimum tenuiflorum*), ‘Mrs. Burns’ Lemon’ (*Ocimum basilicum var. citriodora*), and ‘Pluto Basil’ (*Ocimum minimum*) were germinated and grown at 25 °C, under supplemental lighting provided by red/white/blue (R:W:B) light-emitting diodes (LEDs) providing a PPFD of 90 μmol·m⁻²·s⁻¹ and under eight different photoperiods. Photoperiods were a 9-hour day extended with LEDs providing 2 μmol·m⁻²·s⁻¹ of R:White:far-red (R:W:FR) light to create 11, 12, 13, 14, 15, or 16 h; an additional treatment was a 9-h day with a 4-h night interruption (NI). Time to first visible bud and flower, node number below the first open flower, and plant height at flowering were recorded for each plant. Photoperiod did not significantly influence days to visible bud or flower for ‘Cinnamon’, ‘Genovese’, and ‘Red Rubin’ (*Ocimum basilicum*). However, heights of ‘Cinnamon’, ‘Nufar’, ‘Sweet Thai’, and ‘Red Rubin’ were significantly influenced by photoperiodic treatments. Generally, plants were more compact under shorter day lengths. Flowering of ‘Mrs. Burns’ Lemon’ and ‘Holy basil’ was hastened under 9-h photoperiods. For example, ‘Holy basil’ (*Ocimum tenuiflorum*) under a 9-hour day generally flowered 6, 7, or 10 days earlier than plants under a 15-h, 16-h, or NI treatment, respectively. From this preliminary study, it appears that cultivars investigated of *Ocimum basilicum* var. *citriodora* and *Ocimum tenuiflorum* can be considered facultative short-day plants and *Ocimum basilicum* and *Ocimum xcitriodorum* are day-neutral.

**8:15 AM – 8:30 AM**

**Longer Photoperiods with the Same Daily Light Integral Increase Daily Electron Transport through Photosystem II**

Claudia A. Elkins*
University of Georgia, Athens, GA, USA

Michael Martin
University of Georgia, Athens, GA, USA

Marc van Iersel
University of Georgia, Athens, GA, USA

The annual energy cost for horticultural lighting in the US is approximately $600 million. To lower these costs, it is essential to provide light in a way that allows for efficient photochemistry. Because the quantum yield of photosystem II (ΦPSII), the fraction of absorbed light used for photochemistry, decreases with increasing photosynthetic photon flux density (PPFD), we hypothesized that electron transport through photosystem II integrated over 24 h, the daily photochemical integral (DPI), increases if the same amount of light (daily light integral, DLI) is spread out over longer photoperiods. To test this, we measured chlorophyll fluorescence to determine ΦPSII and the electron transport rate (ETR) of lettuce (*Lactuca sativa* ‘Green Towers’). Plants were grown at a PPFD of ~ 250 μmol·m⁻²·s⁻¹, Chlorophyll fluorescence measurements were taken in a growth chamber equipped with LED lights. A datalogger controlled PPFD and photoperiod and collected ΦPSII and ETR data. DLIs of 15 and 20 mol·m⁻²·d⁻¹, provided over photoperiods of 7, 10, 13, 16, 19, and 22 hours, were tested. PPFD during these measurements ranged from 189 to 796 μmol·m⁻²·s⁻¹. ΦPSII decreased from ~ 0.69 at a PPFD of 189 μmol·m⁻²·s⁻¹ to ~ 0.29 at a PPFD of 796 μmol·m⁻²·s⁻¹, while ETR increased from ~ 54 to 100 μmol·m⁻²·s⁻¹. DPI increased as a function of photoperiod and this increase was more pronounced at high DLI. At a photoperiod of 7 hours DPI was ~ 2.5 mol·m⁻²·d⁻¹, regardless of DLI. However, with a photoperiod of 22 hr and a DLI of 15 mol·m⁻²·d⁻¹, the DPI was ~ 4.2 mol·m⁻²·d⁻¹ (68% higher than with a photoperiod of 7 hr), and with a DLI of 20 mol·m⁻²·d⁻¹ the DPI was ~ 5.5 mol·m⁻²·d⁻¹ (120% higher). Our results show that DPI is significantly higher with lower PPFD over a longer photoperiod than with higher PPFD over a shorter photoperiod, because the light is used more efficiently at lower PPFD. Subsequent longer-term growth trials have shown that longer photoperiods with the same DLI do increase crop growth. These short-term physiological trials, combined with results from longer-term growth trials, indicate that applying supplemental light out over longer photoperiods results in more energy-efficient stimulation of crop growth. This research should encourage growers who use photosynthetic lighting to re-evaluate their current lighting protocols and consider using longer photoperiods.

*Specified Source(s) of Funding: Georgia Research Alliance, American Floral Endowment, USDA-NIFA-SBIR*
Night Interruption with Light-emitting Diodes Applied Using Simulated Moving Greenhouse Booms Promotes Flowering of Petunia ×hybrida
Eric Stallknecht*
University of Georgia, Athens, GA, USA
Marc van Iersel
University of Georgia, Athens, GA, USA

Long-day plants (LDP) require night interruption to promote flowering when grown out-of-season (i.e., early spring). Accelerating flower development shortens the cropping cycle and thus reduces crop inputs like water and fertilization. There are multiple ways to promote flowering in LDP. Cyclic night interruption, night interruption applied in many short periods rather than one long continuous period, is less studied than other methods but can effectively provide night interruption. Many greenhouses use moving booms to apply irrigation, fertilization, and pesticides. Small lighting fixtures attached to these booms can successfully provide cyclic night interruption, often termed “boom lighting”. We hypothesize that boom lighting from light emitting diodes (LEDs) can promote flowering of Petunia ×hybrida as well as traditional methods. A growth chamber with programmable lighting fixtures can accurately mimic moving irrigation booms by gradually increasing and decreasing the provided light intensity. The effects of cyclic night interruption on flowering was tested using night interruption lighting provided at 30-, 60-, 120-, and 240-second intervals between simulated boom passes. Cyclic night interruption applied to seven-week-old petunia seedlings slightly reduced days to first open flower, by up to three days. Our highest cyclic night interruption frequencies, boom passes every 30 and 60 seconds, increased total number of visible inflorescences, but also increased plants height and resulted in less compact plants. To account for additional light from night interruption we also calculated days to flower and the number of inflorescences divided by the total light over a 24-hour period (daily light integral + treatment light integral). This showed that increasing cyclic night interruption frequency does not proportionally reduce days to flower but does proportionally increase the number of inflorescences. Further exploration into the lowest light intensity and lowest frequency that promote flowering are required to make boom lighting more commercially viable.

Specified Source(s) of Funding: American Floral Endowment and Fluence Bioengineering

Quantifying the Influence of Light Intensity and CO₂ Concentration during Sweet Basil Seedling Production on Subsequent Growth, Development, and Volatile Content
Kellie J. Walters*
Michigan State University, East Lansing, MI, USA
Roberto G. Lopez
Michigan State University, East Lansing, MI, USA

Under indoor sole-source lighting (SSL), light intensity and carbon dioxide (CO₂) can be precisely controlled to influence growth, development, and volatile oil content. However, there is currently limited information on physiological and biochemical responses of culinary herbs to varying light intensities and CO₂ concentrations under SSL. Due to increased plant densities during seedling production, fewer inputs per plant are required, creating the potential to increase production efficiency. Therefore, the objectives of this research were to: 1) quantify if light intensity and CO₂ concentration under SSL influence volatile oil content of sweet basil seedlings and if differences remain present through subsequent greenhouse finishing; and 2) determine if light intensity and CO₂ during seedling production influence morphology and yield at harvest. Sweet basil (Ocimum basilicum) ‘Nufar’ seeds were sown in rockwool cubes and placed in a growth chamber with CO₂ concentrations of 500 or 1000 µmol·mol⁻¹. Broad spectrum white light-emitting diodes (LEDs) provided 19:39:39:3 blue:green:red:far-red light ratios (%) and light intensities of 100, 200, 400, or 600 µmol·m⁻²·s⁻¹ for 16-h to create daily light integrals (DLIs) of 6, 12, 23, or 35 mol·m⁻²·d⁻¹. After two weeks, seedlings were transplanted into deep flow technique (DFT) hydroponic systems in a greenhouse with an average daily temperature of 23 °C and DLI of 14 mol·m⁻²·d⁻¹. At transplant and three weeks after transplant, height, leaf area, stem diameter, node and branch number, and fresh and dry mass were recorded and tissue samples were frozen –80 °C for volatile analysis. Relative linalool, eugenol, methyl eugenol, methyl chavicol, and 1,8-cineole concentrations were analyzed using SPME and GCMS. Carbon dioxide and the interaction of CO₂ and DLI did not have an effect on growth or development. However, DLI affected height, leaf area, stem diameter, and fresh and dry mass of seedlings at transplant and height, branch and node number, leaf area, and fresh and dry mass of plants three weeks after transplant. For example, the fresh mass of seedlings increased by 287% as light intensity increased from 100 to 600 µmol·m⁻²·s⁻¹ while subsequent greenhouse grown plant fresh mass increased by 80%. Therefore, environmental parameters under SSL production of seedlings can be used to increase quality and yield.

Yield and Growth of Organically Managed Day-neutral Strawberries in Low Tunnels within a High Tunnel
Tekan Rana*
North Carolina Agricultural and Technical State University, Greensboro, NC, USA
Sanjun Gu
North Carolina Agricultural and Technical State University, Greensboro, NC, USA
John Beck
The Cooperative Extension Program at North Carolina Agricultural and Technical State University, Greensboro, NC, USA
Ocimum basilicum - PPFD - R·s

Lactuca sativa

Brassica

Thus, the 4 treatments received

P. japonica

Lactuca sativa · d -2

dynamically controls supplemental LED light intensity to reach,

used an adaptive LED lighting system in a greenhouse, which

higher intensities and shorter periods. To test this hypothesis, we

synthetic gains, compared to an equivalent amount of light at

intensities over longer periods should lead to increased photo

lower light intensity. Thus, providing supplemental light at low

Photosynthetic responses to light intensity are generally asymp-

totic; light is used more efficiently to drive photosynthesis at

lower light intensity. Thus, providing supplemental light at low

intensities over longer periods should lead to increased photo-
synthetic gains, compared to an equivalent amount of light at

higher intensities and shorter periods. To test this hypothesis, we

used an adaptive LED lighting system in a greenhouse, which
dynamically controls supplemental LED light intensity to reach,

but not exceed, a specified light intensity. Using this system,

‘Little Gem’ lettuce (Lactuca sativa) plants were grown under

a constant daily light integral (DLI) of 17 mol·m⁻²·d⁻¹ provided

over 4 different photoperiods; 12, 15, 18, and 21 hours. The

average DLI in the control treatment (no supplemental light)

was 7.89 ± 3.02 mol·m⁻²·d⁻¹. Thus, the 4 treatments received

slightly more than half of their light from the LED lights.

Threshold light intensity was calculated as: Threshold PPFD

(μmol·m⁻²·s⁻¹) = 1,000,000 × [17 mol·m⁻²·d⁻¹ - Current DLI/Time

remaining (s)]. Hence, while each treatment received the

same amount of light within each 24-h period, extending the

photoperiod allowed the same amount of supplemental light to

be provided at lower instantaneous intensities. The study was

terminated after 22 days. Dry weight increased quadratically

with photoperiod (R² = 0.50, P = 0.003), from an average of

0.53 g/plant with 12-h photoperiods to 0.75 g/plant with 21-h

photoperiods. In the control treatment, average dry weight was

0.17 g/plant. Leaf chlorophyll content and leaf size of the fully

expanded leaves increased linearly as photoperiod increased.

Leaf size increased from 57.2 cm² in the 12-h treatment to 68.2

cm² in the 21-h treatment (P = 0.023), and chlorophyll content

index similarly increased from 9.81 to 12.1 (P = 0.0015). Leaf

area and chlorophyll content were higher in all supplemental

lighting treatments than in the control (P < 0.0001). These

results may be partly attributed to an increased photosynthetic

light use efficiency as photoperiod increased and supplemental

lighting was provided at lower intensities over longer photo-

periods. However, morphological acclimation to photoperiod or

light intensity also occurred, as plants developed larger leaves

with higher chlorophyll content under longer photoperiods. In

conclusion, providing supplemental light in a photochemically-
efficient manner improves overall growth of this lettuce variety.

9:30 AM – 9:45 AM

Effects of Different Photoperiods with Constant Daily Light Integral on Growth and Photosynthesis of Mizuna, Lettuce, and Basil

Shane Palmer*

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Eric Stallknecht

University of Georgia, Athens, GA, USA

Marc van Iersel

University of Georgia, Athens, GA, USA

Most studies of photoperiodic effects on plant growth have used constant instantaneous photosynthetic photon flux densities (PPFD), which leads to different total daily light integrals (DLI) received in each photoperiod. Our objective was to quantify the effect of different photoperiods, all providing the same DLI, on crop growth. Because photosynthesis is more efficient at lower PPFD, we hypothesized that longer photoperiods with lower PPFD would result in faster growth than shorter photoperiods with higher PPFD. Mizuna (Brassica rapa var. japonica), ‘Little Gem’ lettuce (Lactuca sativa), and ‘Genovese’ basil (Ocimum basilicum) were grown from seed
in a controlled environment chamber (20 °C and 800 ppm CO₂) under six photoperiods (10, 12, 14, 16, 18, and 20 h). White LEDs provided light and PPFD was adjusted so each treatment received a DLI of 16 mol·m⁻²·d⁻¹. Mizuna, lettuce, and basil were harvested 30, 41, and 55 d after planting, respectively. Light interception, chlorophyll content, and quantum yield of PSII were positively correlated with duration of photoperiod in all three species. Mizuna plants grown with a 20-h photoperiod had 10.9% greater light interception, 94.6% higher leaf chlorophyll content index, and 10.1% greater quantum yield near the end of the growing period than those grown with a 10-h photoperiod. Lettuce plants grown with a 20-h photoperiod had 11.4% greater light interception, 13.7% higher leaf chlorophyll content index, and 10% greater quantum yield than those grown with a 10-h photoperiod. Mizuna and lettuce plants both also had greater shoot dry mass (28.1% and 18% greater, respectively) when grown with 20-h photoperiods compared to 10-h photoperiods. There was no apparent correlation between photoperiod and dry mass in basil. Basil plants grown with a 20-h photoperiod had 13.7% higher leaf chlorophyll content index and 10% greater quantum yield than those with a 10-h photoperiod. Lettuce plants grown under shorter photoperiods had notably yellower leaves, steeper leaf angle, and more upright growth than those in longer photoperiods. These results show that plants receiving the same DLI can have markedly faster growth when provided light over a longer photoperiod, but the effect appears to be species-specific. This is an important consideration when determining optimal lighting strategies for crop growth. Photoperiod, PPFD, and DLI cannot be studied isolation without accounting for simultaneous effects of the other two variables on plant responses.

*Specified Source(s) of Funding:* Georgia Research Alliance, American Floral Endowment, USDA-NIFA-SBIR

### Vegetable Breeding 1

**Moderator:** Stephanie J. Walker  
New Mexico State University, Las Cruces, NM, USA

8:00 AM – 8:15 AM

**Threshold Vernalization and Dormancy Requirements for Annualization of Long Day Onion Breeding Programs**

Irwin Goldman*  
University of Wisconsin, Madison, WI, USA

Chris D’Angelo  
University of Wisconsin, Madison, WI, USA

Vernalization, the process in which exposure to cold temperatures over an extended period expedites or induces floral initiation, is an important feature for cultivating and producing seed from biennial root vegetables. Onion (*Allium cepa* L.) is biennial and is widely understood to require vernalization to induce flowering. Additionally, long day onion bulbs undergo a period of endodormancy which begins prior to harvest and lasts for several weeks, depending upon the genotype. Understanding the appropriate duration of vernalization and techniques for overcoming bulb dormancy are important for onion breeding and seed production. Endodormant bulbs of two long-day cultivars, ‘Cortland’ and ‘Sherman’ were treated with hydrogen peroxide solutions at various concentrations over a three-year period and were monitored for root and leaf (sprout) development. We found a two to four-hour exogenous treatment of 20% (weight by volume) hydrogen peroxide to be highly effective at initiating uniform root growth in endodormant bulbs. When compared to a purified water control, the 20% treatment resulted in a 61.3% average reduction in the time to rooting in 2016. We also observed improved uniformity in rooting time between ‘Cortland’ and ‘Sherman’ in all three years of this work. A series of time course experiments were conducted over four years with F₁ hybrid and doubled haploid onion bulbs stored at 10 °C for varying lengths of time. For all genotypes, a strong negative relationship was observed for sprouting, scape emergence, flowering, and time from sprouting to scape emergence as storage lengths at 10°C increase. Additionally, the bulb-to-bulb variation in the number of days to conversion showed significant decreases between 10 and 14 weeks of cold storage. We found the optimum chilling time at 10 °C for the genotypes studied to be 14 weeks. However, on a percentage basis, we observed escape emergence and flowering across all cold storage treatment groups, including 90% of the bulbs in treatments which were not exposed to vernalizing temperatures. We propose a combination of precise vernalization with hydrogen peroxide for breaking bulb dormancy as a novel method for breeders, researchers, and seed producers seeking rapid, uniform flowering and seed production in onion in the span of a single calendar year.

8:15 AM – 8:30 AM

**Evaluating Specialty Lima Beans (*Phaseolus lunatus*) As Alternative Crops in Delaware**

Gordon Johnson*  
University of Delaware, Georgetown, DE, USA

Emmalea Ernest  
University of Delaware, Georgetown, DE, USA

Lima bean (*Phaseolus lunatus*) is the most widely grown vegetable crop in Delaware. Green seeded baby lima bean types predominate (over 95% of the crop). Specialty lima beans of other types currently represent less than 5% of the lima beans grown in Delaware. The University of Delaware (UD) initiated a breeding program in 2005, focusing on green baby lima types. In the breeding program, diverse lima bean germplasm is used for crosses and a wide variety of colors, forms, and qualities result in the progeny. Seed of several specialty succulent lima beans already collected or developed as offshoots of the UD green baby lima breeding program have been identified and increased for use in 2018 field trials. This includes three red speckled baby types, two white seeded baby types, 5 multicolored baby types, and one striped Fordhook type. Seed of 12 additional fixed breeding lines from the UD breeding program not previously evaluated and selected germplasm from USDA.
germplasm collections have been identified for increase to use in small plot trials in 2018 and further increase. In addition, an additional 16 indeterminate specialty pole types have been identified and will be used for seed increase in 2018. A collection of 220 diverse lines maintained by the UD lima bean breeding program has been obtained and has evaluated for cooking and eating characteristics for use in further breeding of specialty limas. To evaluate consumer acceptance of available specialty succulent and dry stage lima beans from the UD breeding program, each breeding line was grown to succulent and dry stage in 2017. Succulent seed was shelled from pods, and was then blanched and frozen. Consumer tests were conducted on from Dec. 2017 through March of 2018. Ten succulent and nine dry stage samples were cooked and then used for consumer evaluations. A Hedonic ranking test was performed on the following attributes: overall appearance, color, taste, and texture. Rankings were 5 (like a lot), to 1 (dislike a lot). Tasters were also encouraged to list descriptors including: buttery, nutty, bland, sweet, metallic, or bitter. The specialty lima bean line DE0901201B, which produced a blend of green and white seed when cooked, had the highest overall oganolepic ratings (appearance, color, taste, and texture). Two additional lines DE1002303A (light purple mix when cooked) and DE0900604 Light Red (light purple green mix cooked) had high ratings for taste and texture but lower ratings for overall appearance and color. Dark red and speckled selections that cooked brown to chocolate in color had more mixed ratings for all properties.

8:30 AM – 8:45 AM

Breeding Dwarf Tomato Varieties for Growers in the Northern and Short Season Locations

Ryan Murphy
University of Minnesota, St. Paul, MN, USA

Vincenzo Averello
University of Minnesota, St. Paul, MN, USA

Changbin Chen*
University of Minnesota, St. Paul, MN, USA

Tomato (Lycopersicon esculentum) is native to South and Central America and extensively cultivated throughout the world as a rich source of vitamins and antioxidants valuable to human health. Americans consume nearly 80 pounds per capita each year, making tomato the second most popular vegetable crop behind potato. Most cultivars, however, are adapted to tropical and subtropical climates. These varieties take between 60 and 95 days to mature. Currently, only a few cultivars have been introduced for use in the high northern latitudes. These northern cultivars can reach maturity in 45 days, making tomato production feasible for areas with a short growing season. However, these cultivars often have low yield. This limits growers’ choice of economically valuable fresh tomato cultivars for production in short-season farms and home gardens. Researchers at the University of Minnesota aim to breed cultivars for the Upper Midwest region. Since 2008, the University of Minnesota tomato breeding program has selected 4 dwarf, short season cultivars with high yield and good flavor, including Ground Jewel™, Ground Dew™, MTX851, and MTX956. In this presentation, we report the results collected from our initial selection and farm and home garden trials of these newly developed tomato varieties.

Specified Source(s) of Funding: Minnesota Department of Agriculture, Minnesota Agricultural Experimental Station

8:45 AM – 9:00 AM

Earthy Flavor Due to Geosmin Is Endogenously Produced and Responsive to Selection in Table Beet

Irwin Goldman*
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Lynn Maher
University of Wisconsin-Madison, WI, USA

The flavor profile of table beet is dominated by the earthy-flavored terpene derivative geosmin. Geosmin can be a desired characteristic in beet or a deterrent to the consumption of the vegetable. Geosmin is also produced by Streptomyces spp., various cyanobacteria, and fungi often found in soil and water environments. A long-held presupposition suggests that geosmin production in beets is due to an association with geosmin-producing microbes in the soil. Four beet accessions were grown in an aseptic tissue culture environment. Lack of microbial contamination was demonstrated by sequencing 16S ribosomal RNA to identify potential contaminating microbes. Operational taxa units (OTUs) returned from this analysis were identified as either chloroplast (98%) or mitochondria (2%), demonstrating that beet plants free of microbes were capable of endogenous geosmin production. Bidirectional half-sib recurrent selection for geosmin concentration over four breeding cycles resulted in the development of low (LGC) and high (HGC) geosmin concentration populations. From Year 1 to Year 3, the LGC mean shifted from 17.3–4.3 µg·kg⁻¹ geosmin tissue and the HGC mean shifted from 22.3–33.8 µg·kg⁻¹ geosmin tissue. Taken together, these results demonstrate that geosmin is endogenously produced by beets and is responsive to selection, making it another target trait for breeding.

9:00 AM – 9:15 AM

Progress in New Mexico Green Chile (Capsicum annuum) Cultivar Development for Mechanical Harvest

Israel Joukhadar
New Mexico State University, Las Cruces, NM, USA

Stephanie Walker*
New Mexico State University, Las Cruces, NM, USA

Paul Funk
USDA Agricultural Research Service Southwestern Cotton Ginning Research Lab, Mesilla park, NM, USA

New Mexico green chile (Capsicum annuum L.) is one of New Mexico’s most valuable horticultural crops; however, large-scale
production in New Mexico is at risk due to the high cost and unavailability of labor for hand harvest. Harvest mechanization is critical for the continued strength of the industry. Specific plant architecture is necessary for optimal green chile mechanical harvest efficiency. Taller plants, fewer basal branches, higher primary branch angle heights, and thicker main stem diameters are all plant traits that have been noted to increase the mechanical harvest efficiency of NM type chile. The second year evaluation of green chile breeding lines developed with traits for mechanical harvest efficiency was completed in 2017 at New Mexico State University’s Agricultural Science Center in Los Lunas, New Mexico. Six breeding lines and two commercial cultivars (‘NuMex Joe E. Parker’ and ‘AZ-1904’) were evaluated for plant architectural traits and harvest efficiency with a double, open-helix Moses 1010 mechanical chile pepper harvester. The field was direct seeded on 4 Apr. 2017 in a randomized complete block design with seven replications, then managed according to standard production practices. Plant attributes including plant width, plant height, height to primary branch angle, length between primary branch angle and first node, and stem diameter were measured before harvest. Mechanical harvest yield components, including harvested marketable green fruit, damaged fruit, trash (sticks and leaves), ground fall losses, and unharvested fruit remaining on plants were assessed 29 Aug. 2017. Breeding line 54W17 had significantly higher mechanical yield and the highest harvest efficiency (81%), and breeding line 61W17 had the least marketable yield and lowest harvest efficiency (60%) when mechanically harvested. Breeding line 54W17 also had the highest primary branch angle height, while 61W17 had the shortest primary branch angle height. ‘AZ-1904’ had the thickest pericarp (fruit wall), but also significantly more broken, harvested fruit, indicating that there was no benefit to higher pericarp thickness for reduced fruit breakage in this study. ‘AZ-1904’ had the most ground fall losses and unharvested fruit remaining on plants. We found breeding line 54W17 to be most suitable for mechanical harvest in this trial compared to commercially available cultivars based on overall mechanical harvest efficiency and plant architecture traits. 

Specified Source(s) of Funding: New Mexico Chile Association, New Mexico Chile Commission, and the New Mexico State University Agriculture Experiment Station

9:15 AM – 9:30 AM

Development of Molecular Markers Associated to Spinach Growth Parameters

Henry Awika*
  Texas A&M AgriLife Research, Weslaco, TX, USA
Thiago Marconi
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Juan Enciso
  Texas A&M AgriLife Research, Weslaco, TX, USA
Jinha Jung
  Texas A&M Corpus Christi, Corpus Christi, TX, USA
Carlos Avila

Spinach (Spinacia oleracea L.) is an economically important leafy green crop widely grown in the United States. Spinach production must thrive in a dynamic environment constantly challenged by abiotic and biotic stresses. Such stresses have a profound effect on plant growth and development, ultimately reducing yield. Selecting for resistance and tolerance to these stresses is one of the main focus of breeding programs. Growth rate has direct effect on yield and agronomical practices in the field such as irrigation, fertilization, and harvesting time. With the advancements in next-generation sequencing tools and the completion of the reference spinach genome, as well as the identification of a large panel of SNPs by high-throughput genotyping, it is now possible to identify markers associated to traits of interest to improve breeding efficiency. In order to determine plant growth parameters, a population of 315 spinach accessions from the USDA National Germplasm System and the Texas A&M AgriLife spinach breeding program was monitored from germination to plant senescence using a drone equipped with a RGB camera. Canopy cover, canopy volume, and plant height for each accession was measured once a week. Changes on those parameters between measurements were used to determine crop growth rates. Genotype by sequencing was performed (GBS) using ddRADSeq. Genome-wide association (GWAS) analysis was performed to develop molecular markers associated with plant growth variables using mixed linear model (MLM) from TASSEL and GAPIT. Identification of molecular markers associated with crop growth parameters will facilitate selection and development of cultivars with improved agronomic characteristics. Furthermore, changes in growth rates can be used to screen breeding populations for resistance and tolerance to biotic and abiotic stresses.

Specified Source(s) of Funding: USDA-NIFA-SCRI 2017-51181-26830 and Texas A&M AgriLife Vegetable Seed Grant

9:30 AM – 9:45 AM

Comparison of Tomato Genotypes Grown Under Conventional and Organic Production System for Nutrient Composition and Fruit Quality

Dilip R. Panthee*
  North Carolina State University, Mills River, NC, USA
Penelope Perkins-Veazie
  North Carolina State University, Kannapolis, NC, USA

Recently organic vegetable market is growing rapidly. There is a wide perception that organic product is better than conventional product. However, there are little data to support this claim. Because of this perception, there is a growing interest in the fruits and vegetables produced under organic production system. While some of the reports on subjective comparison of quality of fruits and vegetables produced under conventional and organic systems are already available, we were interested to determine the genotypic differences under conventional and organic pro-
Ornamentals/Landscape and Turf

Moderator: Mary Meyer
University of Minnesota, Chaska, MN, USA

8:00 AM – 8:15 AM

Few Residual Effects of Planting Stock Size Remain Five Years after Transplanting to the Landscape
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Three species of trees, *Vitex agnus-castus* L. (an unnamed white flowering clone), *Acer rubrum* L. var. *drummondii* (Hook. & Arn. ex Nutt.) Sarg. ‘Maroon’, and *Taxodium distichum* (L.) Rich. (test clone TX8DD38) were propagated clonally in a sequential manner over two growing seasons and transplanted to consecu-
one another of the three species in five different container sizes of 3.5, 11.7, 23.3, 97.8, or 175.0 L. No differences were present among the heights of the three largest container sizes the end of the fifth growing season and the *T. distichum* trees from the two smaller size containers lagged only slightly behind. For trunk diameter, no differences were present among trees from the various container sizes by the end of the fifth growing season for *V. agnus-castus* and *A. rubrum*, and only the trees from 3.5 L containers had statistically smaller trunk diameters than those from larger containers for *T. distichum*. No differences in canopy spread were present in *V. agnus-castus* by the end of the second growing season, *A. rubrum* by the end of the fourth growing season, and *T. distichum* by the end of the fifth growing season. If one is willing to forego the immediate aesthetic impacts, ecosystem services, and greater ability to withstand mechanical damage of larger-size container stock, similar longer-term sizes in the landscape can be achieved by transplanting less expensive, more easily handled, smaller container-size trees.

Specified Source(s) of Funding: Support for this project was provided by the Tree Research and Education Endowment (TREE) Fund and Hatch funding from the National Institute of Food and Agriculture (NIFA).

8:15 AM – 8:30 AM

Salting the Earth: An Emerging Issue in Green Infrastructure Systems?
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Salinity stress in plants is typically regarded as an issue of dryland and maritime regions. However, salinity stress is also a concern along roadways in inland mesic regions, where winter precipitation and freezing temperatures warrant the use of salt for safety. Salt is frequently used to melt snow and ice on roadways, sidewalks, and parking lots during winter months, but its use can be extremely damaging to the urban landscape due to the high concentration of sodium in city water supplies. Residues of sodium are often spread by city plows, eventually washing into creeks and streams that drain to the ocean, and contribute to salt loading in coastal areas along the eastern seaboard. As symptoms of salinity stress are often hard to distinguish from those due to other abiotic or biotic stressors, it is imperative to understand salinity stress impacts on urban trees and develop mitigation strategies. The purpose of this project was to provide objective data regarding urban tree health in salt-impacted areas. Specimen trees were selected in salt-impacted areas in coastal Georgia. Trees were monitored to time irrigation to avoid systematically over or under-irrigating the different species and size trees. Height, trunk diameter, and canopy spread were measured at transplant and then at the end of each growing season in the field for the next five years. After just two growing seasons in the field trees from the four larger containers of *V. agnus-castus* did not differ statistically (*P < 0.05*) in height, with only the trees from the 3.5 L containers lagging behind. By the third year no differences in height were found among trees from all five container sizes of *V. agnus-castus*. *Acer rubrum* trees did not differ in height among the various container sizes by the end of the fourth growing season. For slower growing *T. distichum* trees no differences existed among the heights of the three largest container sizes by the end of the fifth growing season and the *T. distichum* trees from the two smaller size containers lagged only slightly behind. For trunk diameter, no differences were present among trees from the various container sizes by the end of the fifth growing season for *V. agnus-castus* and *A. rubrum*, and only the trees from 3.5 L containers had statistically smaller trunk diameters than those from larger containers for *T. distichum*. No differences in canopy spread were present in *V. agnus-castus* by the end of the second growing season, *A. rubrum* by the end of the fourth growing season, and *T. distichum* by the end of the fifth growing season. If one is willing to forego the immediate aesthetic impacts, ecosystem services, and greater ability to withstand mechanical damage of larger-size container stock, similar longer-term sizes in the landscape can be achieved by transplanting less expensive, more easily handled, smaller container-size trees.
deicing salt. In this context, stormwater runoff has historically been channeled into local streams and rivers, but there are rapidly expanding efforts to divert roadway runoff into green infrastructure elements such as raingardens and bioswales. Salinity could therefore become an increasing challenge as more vegetated stormwater infrastructure systems are installed along roadways. As part of an investigation on plant health in bioswales that capture runoff from a section of Interstate 95 in Philadelphia, we measured soil electrical conductivity (EC) to assess sodium chloride levels across a topographical gradient. In June and August 2017, EC1:5 was measured in soils beneath 72 focal plants; it ranged from 0.34–0.78 and 0.13–0.80 dS/m, respectively, the highest values of which are indicative of “high” soil salinity. Monthly measurements were made in the spring of 2018 at 18 sampling locations spanning topographically low and high areas. Soils reached “severe” salinity levels in January (EC range = 0.08–2.11 dS/m) and February (0.12–2.85 dS/m), and “extreme” levels in March (0.09–4.2 dS/m). Areas of elevated EC1:5 correlated spatially with the flow paths of storm water, low lying areas, and depressions where pooling occurs. These results provide support to a hypothesis that salinity stress is contributing to topographic differences in plant growth. Further data collection efforts will determine if high salinity persists in the soil into the growing season, and if water stress and/or toxicity responses are directly evident in plants.

*Specified Source(s) of Funding:* Pennsylvania Department of Transportation and AECOM

8:30 AM – 8:45 AM

**Prairie Dropseed Germination**

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*Sporobolus heterolepis,* prairie dropseed, is a warm season grass native to upland, drier sites in central and northeastern U.S. An attractive bunchgrass with numerous fragrant flowers and yellow fall color, prairie dropseed should be used more in urban plantings where native grasses provide ecosystem services such as reduced runoff, minimal soil erosion and food sources for native Lepidoptera larvae. A survey of grass growers confirmed that this species often has low seed germination rates and can be a slow, difficult plant to increase with crown division. Seed quality and germination techniques were investigated using commercially available seed as well as garden and wild collected seed from locations in Minnesota and Wisconsin. Although historic germination research has not shown cold moist seed treatments to improve germination, some growers do use this as standard treatment for prairie dropseed. Cold moist treatments in soil or petri plates were compared to cold dry seed treatments. Seed purity, germination and tetrazolium staining varied depending on seed source, age and treatment. Cleaning, grading and pre-germination examination of seed, using fresh seed, and maintaining consistently moist conditions appear to be requirements for the highest germination of prairie dropseed.

An asterisk (*) following a name indicates the presenting author.
Cercospora leaf spot of roses is a fungal disease caused by the pathogen *Rospisphaerella rosicola* (teleomorph: *Mycosphaerella rosicola*, syn: *Passalora rosicola*, *Cercospora rosicola* Pass.). It mainly causes lesions on the leaves, and in severe cases, chlorosis and defoliation. This disease seems to be especially prevalent in the southern region of the United States. Disease severities and landscape traits were evaluated monthly in replicated field trials in both College Station and Overton, Texas during 2016–17. The rose trials were a mix of species, modern hybrid and modern shrubs. They were rated on a 0–9 scale which is percentage based with respect to the number of cercospora lesions on the rose canopy. Overton had higher cercospora ratings during both years (2.66 and 3.45) than College Station (0.44 and 1.28). This is due to the higher inoculum and precipitation in Overton. The temperature and humidity were similar in both locations. There was a wide range for cercospora incidence on roses for both years, in which ~20% of the accessions had less than a rating of 5 in Overton and in College Station, only one rose accession had a rating over 5. Only seventeen and seven rose accessions showed no cercospora lesion in College Station in 2016 and 2017, respectively, while in Overton, five rose accession had no cercospora lesions in 2016 and three showed no lesions in 2017. The incidence of cercospora leaf spot was negatively correlated with black spot and weakly negatively correlated with defoliation in both locations. This may be explained by the effects of black spot and other environmental factors on defoliation.

Specified Source(s) of Funding: USDA’s National Institute of Food and Agriculture (NIFA) Specialty Crop Research Initiative project, “Combating Rose Rosette Disease: Short Term and Long Term Approaches” (2014-51181-22644/SCRI)

9:15 AM – 9:30 AM

**Mid-winter Hardiness and Seasonal De-acclimation Response of Some Evergreen Azaleas**

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Occurrences of extreme temperature fluctuations during late winter/early spring can subject overwintering perennials to unseasonal de-acclimation. Consequently, these dehardened plants become vulnerable to returning freezing temperatures. Freeze-damage from such scenario to economically important horticultural species has been noted in recent years with increasing frequency. But little is known about the physiology of de-acclimation response (timing and speed). To that end, mid-winter hardiness and seasonal de-acclimation were investigated during January to March 2014 in the leaves of 10 evergreen azalea cultivars (*Rhododendron* section *Tsutsusi*) (‘Changchunerhao’, ‘Dazhusha’, ‘Elsie Lee’, ‘Hongshanhu’, ‘Nuccio’s Pink Bobble’, ‘Shiyandujuan’, ‘Yudaizhirong’, ‘Zuangyuanhong’, ‘Zihudie’, and ‘Zi’e’) grown under natural conditions in eastern China. Leaf samples were collected bi-weekly and leaf freezing tolerance (LFT) was evaluated using a temperature-controlled freeze-thaw protocol followed by ion-leakage-based injury assessment. Based on the mid-winter/cold-acclimated LFT, these cultivars were grouped as “more-hardy” (‘Changchunerhao’, ‘Elsie Lee’, ‘Nuccio’s Pink Bobble’, ‘Shiyandujuan’, and ‘Yudaizhirong’) versus “less-hardy”. ‘Elsie Lee’ was the hardest and ‘Dazhusha’ was the least-hardy in midwinter. Eight of the 10 cultivars first showed de-acclimation when daily mean temperature over two-week period preceding the LFT measurement was ~9.5 °C. De-acclimation for other two cultivars (‘Nuccio’s Pink Bobble’ and ‘Shiyandujuan’) was somewhat delayed and might have involved “de-acclimation-reacclimation” cycling before eventual de-acclimation. Our data indicate that the “more-hardy” group de-acclimated slower than the “less-hardy” ones over the first half of the de-acclimation period. This trend reversed during second half of the de-acclimation period. Accordingly, “more-hardy” and “less-hardy” cultivars depicted a “curvilinear” and “reverse curvilinear/linear” de-acclimation kinetics, respectively. Though somewhat preliminary, these results may indicate suitability/ vulnerability of these cultivars to various scenarios of changing climate; for example: “more-hardy” group may survive hard frosts after unseasonal warm spells during midwinter, whereas “less-hardy” group could survive sudden frost in the early spring. “More-hardy” cultivars generally had higher total soluble sugars (TSS) than “less-hardy” ones at acclimated state. TSS declined during de-acclimation in all cultivars and the loss was positively correlated with the loss in LFT. Leaf starch content generally followed opposite trend to that of TSS, i.e. it was at lowest during acclimated state and increased during de-acclimation.

Specified Source(s) of Funding: Zhejiang Province, China (Project- ‘The evaluation of germplasm resources and variety breeding of azaleas’ - 2016C02056-12)
An Investigation on the Impact of Compost Tea Applications on Turf Quality and Soil Microbial Activity

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The purpose of this study was to investigate the effect of compost tea applications on overall turf quality and soil microbial activity. Two 60 ft² bermudagrass (Cynodon dactylon) study sites were included in the study. Each site was divided into a 30 ft² control and a 30 ft² treatment area. One study site received artificial irrigation while the other did not. Compost tea was created using an industrial-sized compost tea brewer (Erath Earth, Dublin, TX). The compost tea recipe included water, air, finished compost, ammonium nitrate and molasses and was applied to study sites within two hours of brewing. The study utilized the soil drench method of application where each treatment area received twelve gallons of compost tea applied by hand. Both study areas were maintained normally by landscape maintenance crews which included regular mowing but no fertilizer applications. Fifteen soil samples and turf quality observations were first drawn for pretest data and then taken after each of three additional seasonal test periods over the course of one year for each of the four locations (irrigated and non-irrigated control and treatment sites). A point intercept method was used to sample plots randomly. Evaluations of turfgrass were based on The National Turfgrass Evaluation Program’s guidelines for turfgrass evaluation and included measuring color, turf density, overall density, percent living and texture. Soil samples were drawn and analyzed for microbial activity using tetrazolium tests. Results presented provide evidence on the value of compost tea to overall turf quality and beneficial soil microbial populations.

9:45 AM – 10:00 AM

2,4-D Antagonism from Tank-mixtures with Iron Fertilizers

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Iron (Fe) is commonly used in the turfgrass industry to correct nutrient deficiencies in high pH soils, for disease suppression, moss suppression, or improved turf aesthetics. Particularly in the lawn care industry, Fe may be tank-mixed with 2,4-D containing herbicides to control weeds in the lawn while simultaneously providing Fe nutrition. Since FeSO₄ is known to antagonize certain herbicides and since other cations are known to antagonize water soluble 2,4-D formulations, our objective was to evaluate the influence of various sources of iron on 2,4-D dimethylamine efficacy when tank-mixed. Greenhouse and field experiments evaluated three iron sources: FeSO₄ heptahydrate, Fe diethylenetriaminepentaacetic acid (DTPA), and Fe hydroxyethylenediaminetriacetic acid (HEDTA). FeSO₄ and FeDTPA are commonly marketed for nutrition, whereas FeHEDTA is marketed for broadleaf weed control. Iron application rates were chosen based on label recommendations or common use rates. The iron sources were applied to dandelions with or without 2,4-D dimethylamine at 1.6 kg ae ha⁻¹ in the greenhouse experiment. The field experiment applied six treatments (nontreated, 2,4-D + FeSO₄, 2,4-D + FeDTPA, 2,4-D + FeHEDTA, and FeHEDTA) to dandelions in Oct. 2016 and 2017. Without the inclusion of 2,4-D, FeHEDTA reduced dandelion mass compared to other iron sources and the nontreated plants in the greenhouse experiment. This was from a rapid injury to dandelion foliage from FeHEDTA after application followed by a partial recovery of the dandelion. Both 2,4-D applied alone and 2,4-D tank-mixed with FeHEDTA, controlled dandelions in the greenhouse experiment. However, both FeSO₄ and FeDTPA reduced weed control when tank-mixed with 2,4-D. In the field, 2,4-D alone provided the highest control of mature dandelions and superior control to a single application of FeHEDTA alone. All three iron sources (FeSO₄, FeDTPA, FeHEDTA) antagonized 2,4-D when applied as tank-mixtures to field plots. Overall, results suggest that each of the iron fertilizers can antagonize 2,4-D dimethylamine and that applicators should avoid tank-mixing iron fertilizers when applying postemergence broadleaf herbicides.

Vegetable Crops Management 2

Moderator: David Suchoff
North Carolina State University, Raleigh, NC, USA

8:00 AM – 8:15 AM

Grafted Tomato Shoot and Root Responses to Drying Soils

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Improvement of crop water use is imperative. How plants respond to limited water can dictate their ability to better utilize available resources and avoid prolonged and severe stress. The following study was conducted to determine how tomato (Solanum lycopersicum) rootstocks with different root system morphologies...
Oral Presentations

Improving Tomato Cold Tolerance through Grafting

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Solanum lycopersicum

An asterisk (*) following a name indicates the presenting author.

Tomatoes (Solanum lycopersicum) are a warm-season, cold-sensitive crop that show depression in growth and development with temperatures below 18°C. Improving suboptimal temperature tolerance would allow for earlier planting of field-grown tomatoes as well as a reduction in energy inputs for heating greenhouses. Grafting tomatoes onto high-altitude wild Solanum habrochaites accessions has proven effective at improving scion suboptimal temperature tolerance. The following study was conducted to determine whether commercially available tomato rootstocks with differing parental backgrounds and root system morphologies can improve scion suboptimal temperature tolerance. Two controlled environment growth chambers were utilized and maintained at either optimal (25 °C day / 20 °C night) or suboptimal (15 °C day / 15 °C night) temperatures. The cold-sensitive tomato cultivar Moneymaker was used as the non-grafted and self-grafted control as well as scion on ‘Multifort’, ‘Shield’, and S. habrochaites LA 1777 rootstocks. We found that ‘Multifort’ rootstock significantly reduced the amount of cold-induced leaf area reduction and maintained higher levels of CO₂ assimilation and photosystem II quantum efficiency. ‘Multifort’ maintained significantly longer roots, having 42% to 56% more fine root (diameter less than 0.5 mm) length compared to the other rootstock treatments. Leaf starch concentration was significantly lower in ‘Multifort’-grafted plants at suboptimal temperatures. The ability for ‘Multifort’ to maintain root growth at suboptimal temperatures may improve root system sink strength, thus allowing for proper movement of photosynthesate from leaf to root even under cold conditions. This study represents one of the first attempts to characterize whole root system morphology responses in tomato rootstocks at suboptimal temperatures. Furthermore, we show that commercially available rootstocks can be selected to improve suboptimal temperature tolerance in cold-sensitive scions at early stages of plant development.

Specified Source(s) of Funding: NIFA USDA award # 2016-51181-25404

8:15 AM – 8:30 AM

8:30 AM – 8:45 AM

In the Absence of Soil-borne Disease Pressure, Does Tomato Grafting Still Benefit Midwest Vegetable Growers?

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In the absence of soil-borne disease, tomatoes grafted to hybrid rootstock RST-04-106-T showed minimal yield increase. This result indicates the need for more trials of tomato rootstocks that meet the need of localized soil conditions in the Midwest, and our additional research was designed to address this gap in localized rootstock performance data. We hypothesized that alternative rootstocks would outperform non-grafted plants even without the effect of soil-borne disease. Our research objectives were to assess marketable yield, fruit quality (soluble solids, titratable acids, and firmness), and plant growth characteristics (SPAD,
plant height, stem diameter, petiole-sap, and biomass) of eight different hybrid tomato rootstocks compared to a self-grafted and non-grafted control. Hybrid tomato BHN 589 was grafted to all rootstocks in addition to non-grafted and self-grafted controls. The rootstock treatments included commercially available Arnold, Beaufort, DRO141TX, Estamino, Maxifort, RST-04-106-T, and two trial rootstocks not yet commercially available, 946 TRS and 980 TRS. This research took place during 2017 in a 9.1 x single-poly high tunnel in central Iowa. There were five plants per plot in a randomized complete-block design with five replications. The crop was harvested thirteen times between 5 July and 27 Sept. Non-grafted and self-grafted plants had the lowest marketable yield per plant with means of 5.5 and 5.6 kg respectively. Plants grafted to Maxifort, DRO141TX, and Estamino had the highest marketable yield ranging from 8.1 to 8.6 kg per plant. Fruit total soluble solute concentration ranged from 4.6 °Brix (Maxifort rootstock) to 5.4 °Brix (RST-04-106-T rootstock). Estamino and Arnold had the largest mean root biomasses of 21.0 and 19.1 g, respectively. Shoot biomass was largest for tomatoes grafted on Maxifort (323.1 g) and Estamino (320.7 g) rootstocks. Our results indicate that grafting tomatoes may still be a viable option for Iowa vegetable growers even in the absence of soil-borne disease. This work identifies several rootstocks that are well-suited for high tunnel production systems in the Midwest.

8:45 AM – 9:00 AM

**High Tunnel and Field Production System Comparison of Grafted Tomato in Texas**

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Successful integration of vegetable grafting into current tomato production practices could open new opportunities for the Texas tomato industry to exploit vigorous rootstocks for effectively managing soil diseases, abiotic stresses, and improve fruit quality and yield. A multi-location (Uvalde, Overton, and Weslaco) trial was conducted to evaluate the yield performance of grafted tomatoes in protected environment and open-field conditions during the growing season of spring of 2017. In each location, two determinate tomato cultivars, TAMU Hot and Tycoon, were grafted onto two interspecific hybrid rootstocks, ‘Estamino’ and ‘Multifort’. Non-grafted ‘TAMU Hot’ and ‘Tycoon’ were used as controls. Field experiments were arranged in a randomized complete block design with four to five replications, depending on location. Yield performance of the graft combinations varied with location and production system. In the Uvalde location, the high tunnel system enhanced marketable yields by 116% to 161% relative to open-field system, with an additional of 8% to 23% significant increase due to grafting with interspecific rootstocks. Yield increase in grafted plants was mainly due to significant increases in average fruit weight. In the Overton location where only open-field trial was conducted, grafting ‘Tycoon’ on ‘Estamino’ and ‘Multifort’ significantly increased the marketable yield by 59% and 44%, respectively, as compared to the non-grafted control. Similar yield increases due to the grafting were also achieved under open-field conditions in the Weslaco location, although yield levels were generally lower than those of other locations. Results from this study demonstrate that grafting along with protected environment system clearly have the potential to significantly increase tomato production across Texas regions.

**Specified Source(s) of Funding:** Texas A&M AgriLife Vegetable Seed Grant

9:00 AM – 9:15 AM

**Anaerobic Soil Disinfestation and Herbicide Effects on Nutrient Cycling, Plant Growth, and Yield of Fresh-market Tomato**

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Anaerobic soil disinfestation (ASD) is a non-fumigant pre-plant soil disinfestation technique proposed for the management of soilborne pests and diseases. In Florida, ASD is applied by amending the soil with sugarcane-molasses (C-source) and composted poultry-litter (CPL), irrigation to soil saturation, amending the soil with sugarcane-molasses (C-source) and composted poultry-litter (CPL), irrigation to soil saturation, followed by mulching with totally impermeable film (TIF). While ASD may provide higher yields compared to the standard chemical soil fumigation (CSF), its large-scale application is currently limited by the cost of the C-source. Moreover, there
are concerns regarding the fate of the nutrients applied with the amendments combined with soil saturation, especially in terms of nitrous oxide emissions and nutrient leaching. Therefore, a study was performed in Immokalee, FL, on fresh-market tomato during the Fall 2015 season to investigate nutrient dynamics. Standard CSF with Pic-Clor 60 was compared with ASD application using two rates of organic amendments: ASD1 (13.86 m\textsuperscript{3}·ha\textsuperscript{-1} molasses and 22 Mg·ha\textsuperscript{-1} CPL) and ASD0.5 (6.93 m\textsuperscript{3}·ha\textsuperscript{-1} molasses and 11 Mg·ha\textsuperscript{-1} CPL), in combination or not with the pre-emergence herbicide halosulfuron-methyl. Treatments were arranged in a split-plot design with four replications. The objective of the study was to determine the impact of the treatments on soil redox-potential, plant growth, fruit production, and nutrient fate. During the three-week treatment, both ASD treatments achieved similar anaerobic conditions, regardless of herbicide application. Nitrous oxide emissions were minimized by the TIF during the three-week treatment, and only immediately after punching were higher with CSF than with ASD. At the same time, both ASD1 and ASD0.5 increased the availability of K in the soil solution compared to CSF. Conversely, 7 days after treatment (DAT), NO\textsubscript{3}- concentrations in the soil solution were 86% lower in ASD compared to CSF. At transplanting (21 DAT), ASD increased P and K soil content compared to CSF, and increases were proportional to amendment rate, regardless of herbicide application. At 58 days after planting, above-ground total plant dry-weight was 82% and 41% higher with ASD1 and ASD0.5 than CSF, respectively; while herbicide application had no effect. Consequently, plant nutrient accumulation was positively affected by ASD and by increasing amendments rate, but it was not influenced by herbicide application. In conclusion, ASD showed lower risk of N loss compared to CSF, while herbicide application increased the availability of P and K for the crop. Therefore, the crop fertilization program should be adjusted considering the input of nutrients associated with the application of molasses and CPL.

*Specific Source(s) of Funding:* USDA, ARS, Areawide Project on Anaerobic Soil Disinfestation.

9:15 AM – 9:30 AM

**Interaction between Bell Pepper Rootstocks and Phytophthora Capsici under Salinity Stress**

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Bell pepper is the second leading vegetable crop in Florida. The profitability of bell pepper has been endangered by the increasing incidence of *Phytophthora capsici*, an important soilborne plant-pathogen known for its destructive potential, especially in subtropical areas. While periods of high rainfall and raised water levels are considered major causes of *P. capsici* outbreaks, the incidence of the disease seems to be favored by salinity stress, a condition increasingly affecting the coastal areas of South Florida, where a significant amount of bell pepper production occurs. Under such conditions, vegetable grafting may represent a potential solution to manage both biotic and abiotic stress. Therefore, a greenhouse pot-study was conducted to evaluate the plant growth, nutrient accumulation, yield, and stress response of different bell-pepper grafting combinations to *P. capsici* in presence of 0, 30, and 60 mM of NaCl. Non-grafted and self-grafted plants of ‘Blitz’ (susceptible to *P. capsici*) were compared with plants grafted onto ‘Dorado’ and ‘Robusto’, both commercial rootstocks claimed to be resistant to *P. capsici*. Plants were grown in pots on a sandy-soil:perlite mix (50:50, v:v) and fertigated daily through drip-irrigation. Salinity treatments started 14 days after planting (DAP) and plants were inoculated with *P. capsici* at 28 DAP. At 64 DAP, all three factors affected plant growth and a significant interaction was observed among all three factors for leaf area and leaf dry weight. Significant three- and two-factor interactions were also observed for most measured plant nutrient accumulation parameters. Total-plant sodium accumulation increased with increasing salinity level, while a significant interaction was observed between *P. capsici* and rootstock. At harvest, total fruit number and fruit fresh weight per plant were affected by salinity level and grafting combination, and a significant interaction was observed between grafting combination and *P. capsici*. A significant interaction between the three factors was also observed for disease incidence. In infested soil, non-grafted and self-grafted plants of ‘Blitz’ showed consistently higher incidence of Phytophthora blight compared to those grafted onto ‘Dorado’ and ‘Robusto’. Moreover, plants grown under moderate salinity (30 mM of NaCl) had a higher disease incidence compared to those grown with 0 and 60 mM of NaCl. It is concluded that irrigation with moderately saline water may increase the incidence of Phytophthora blight in susceptible cultivars of bell pepper. However, commercial rootstocks resistant to *P. capsici* may assure the control of the disease either with no, moderate, or moderately-high salinity levels.

*Specific Source(s) of Funding:* Growing New Roots: Grafting to Enhance Resiliency in US Vegetable Industries

9:30 AM – 9:45 AM

**Effects of Humic Substances and Growth Environments on the Rhizosphere Microbial Biomass in a Bell Pepper System**

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The microbiota in the root rhizosphere is essential for mutualistic benefits with plant growth. Due to the dynamic and complex environment, the community of rhizosphere microbes is highly affected by root growth and abiotic factors. Humic substances (HS) are widely used as soil organic amendments to improve plant root growth and soil properties, and also to enhance soil microbial activities due to the additional carbon input. However, there is limited information on the effects of HS on the rhizosphere microbial composition, especially in vegetable crop systems. In this two-year field experimental study, we applied HS as carbon input, and evaluated their responses under two distinctive environmental factors: soil type (clay, sandy) and water content (deficit, well-watered) to illustrate the shaping effects of abiotic factors on the microbial activity of a bell pepper rhizosphere. The results using a path analysis revealed that soil type was the main factor driving the microbial changes. Clay soil tended to increase bacteria population through changes in root length, soil pH and K content, and fungus population through the enhancement in pepper yield. HS application acting as organic input may have a long-term positive influence on soil microbial activity through improvements in soil organic carbon content, and this benefited more to bacteria community. Water content became a less influential factor compared to soil type and organic input on the microbial activity. Higher water content tended to increase fungal biomass but decrease soil respiration through the enhancement in pepper aboveground growth. This study distinguished key abiotic factors that affected the rhizosphere microbial biomass in a bell pepper growth system, which can act as a reference to establish applied approaches to improve the persistence and benefits from rhizosphere microbial community.  
Specified Source(s) of Funding: NOVIHUM TECHNOLOGIES GMBH

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Root Growth and Rhizosphere Dynamics/Invasive Plants Research

Moderator: Lyn A. Gettys  
University of Florida Ft Lauderdale Research and Education Center, Davie, FL, USA

9:30 AM – 9:45 AM

Temperature Effects on Root Respiration Rate of Heat Tolerant and Intolerant Tomato Varieties

George Guenthner*  
University of Minnesota, St Paul, MN, USA

John Erwin  
University of Minnesota, St. Paul, MN, USA

Eight tomato cultivars (Accession LA-1994, ‘Nacgarlang’, ‘Saladette’, ‘Campbell-28’, ‘Moskvich OG’, ‘Amana Orange’, ‘Solar Set’, and ‘Solar Fire’) previously identified as heat tolerant or intolerant based upon photosynthesis and/or yields were compared for variation in root respiratory temperature thresholds. Root respiration rates were measured at temperatures...

An asterisk (*) following a name indicates the presenting author.
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Oral Presentations

9:45 AM – 10:00 AM

Unravelling Direct and Nutrient Uptake-dependent Rhizosphere Acidification in Southern Highbush Blueberry

Gerardo H. Nunez*
University of Florida, Gainesville, FL, USA
Christopher S. Imler
University of Florida, Gainesville, FL, USA
Camila I. Arzola
University of Florida, Gainesville, FL, USA

Soil pH is a major factor affecting horticultural productivity. Site selection and soil amendments are routinely used to provide optimum pH for cultivation. Nevertheless, some plants are capable of changing the pH in their rhizospheres. Plants acidify their rhizosphere by means of H+-ATPase-mediated proton extrusion (direct rhizosphere acidification) and/or as a consequence of nutrient uptake (nutrient uptake-dependent acidification). N uptake—in particular—can have large effects in rhizosphere pH. Nitrate uptake leads to rhizosphere alkalization, whereas ammonium uptake leads to rhizosphere acidification. Acid-loving plants (family Ericaceae) thrive in acidic soils where ammonium is the most prevalent form of N. Thus, these plants could exhibit both direct and nutrient uptake-dependent acidification. The relative importance of both of these processes for acid-loving plants is unknown. We hypothesized that ammonium uptake plays a greater role than H+-ATPase activity in the rhizosphere acidification of acid-loving plants. We grew one-year-old rooted cuttings of southern highbush blueberry ‘Emerald’ (SHB, Vaccinium corymbosum interspecific hybrids) in a split-root hydroponic system where each half of the root system was in a different reservoir. One reservoir was supplied with a buffered, complete nutrient solution containing 2.5 mM ammonium. The other reservoir was supplied with a non-buffered nutrient solution containing either 2.5 mM ammonium or no nitrogen. Plants were arranged in a completely randomized design with two treatments (NH₄⁺ buffered/NH₄⁺ non-buffered and NH₄⁺ buffered/none). We measured rhizosphere pH, N uptake from solution, tissue N concentration, and root electrolyte leakage (REL). Additionally, we measured the expression of genes that encode glutamine synthetase (GS) and plasma membrane-bound H⁺-ATPases. We found that N uptake and tissue N concentrations were not different between plants in both treatments. Additionally, roots in all reservoirs exhibited similar REL, suggesting the split-root hydroponic system did not stress the root systems. Nutrient solution pH measurements indicated that SHB exhibits both direct and nutrient uptake-dependent rhizosphere acidification. Gene expression data supported this notion. Furthermore, ammonium uptake acidified the rhizosphere at a significantly higher rate than H⁺-ATPase activity. Altogether, these results suggest that nutrient uptake-related rhizosphere acidification plays a pivotal role in promoting adequate soil pH for cultivation of SHB and other acid-loving plants.

Specified Source(s) of Funding: USDA-ARS; FRA; Minnesota Agriculture Experiment Station

10:00 AM – 10:15 AM

Recent Advancements in Mapping and Evaluation of Tree Root Systems with Ground Penetrating Radar

Dilruba Yeasmin*
California State University Fresno, Fresno, CA, USA
John T. Bushoven
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Charles F. Krauter
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Anthony Mucciardi
TreeRadar Inc., Silver Spring, MD, USA
Allen Vizcarra
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Tree Root Mapping with Ground Penetrating Radar (GPR) is a non-invasive/non-destructive method of studying underground root distribution. Although there has been some application of this technology over the past few decades, the feasibility, efficiency, and accuracy of this method have not been widely examined. Recent advances in hardware and software have fostered a need to revisit use of such technology in agriculturally and horticulturally important tree species. Such applications have the potential to monitor root growth and health in a wide range of environments, including orchards or urban forests. To date, there have also been few studies directly focused on assessing such in intact, live root systems in undisturbed soil profiles. To address such this study utilized a state-of-the-art

An asterisk (*) following a name indicates the presenting author.
Oral Presentations

10:15 AM – 10:30 AM

Mesocosm Trials to Evaluate Herbicide Efficacy on Submersed Plants

Lyn A. Gettys*
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Kyle L. Thayer
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Ian J. Markovich
University of Florida Fort Lauderdale Research and Education Center, Davie, FL, USA

South Florida relies on a system of interconnected canals to prevent flooding of the mostly flat topography during severe storms. These canals must be kept free of dense vegetation to ensure that stormwaters can flow unobstructed. Aquatic nuisance species that hinder water movement in canals include crested floatingheart (Hygrophila polysperma), fanwort (Cabomba caroliniana) and hygrophila (Hygrophila polystigma). Replicated mesocosm studies conducted in a covered greenhouse in south Florida utilized a single water-column treatment of one of 33 treatments (11 aquatic herbicides alone or in combination with another herbicide, plus an untreated control). After 16 weeks of culture under experimental conditions, mortality of all three species was greatest in mesocosms treated with ProcellaCOR, triclopyr, triclopyr+diquat, penoxsulam, penoxsulam+diquat, penoxsulam+flumioxazin, imazamox+diquat, imazamox+flumioxazin, carfentrazone and carfentrazone+diquat. These results suggest that resource managers in south Florida have a number of chemical tools at their disposal to manage aquatic weeds in canals. These findings are valuable because reliance on a single active ingredient can drive the development of herbicide resistance by selecting for resistant genotypes.

Specified Source(s) of Funding: California State University Fresno Agricultural Research Institute Grant

10:30 AM – 10:45 AM

Development of Sterile Non-invasive Euonymus alatus for the Ornamental Industry

Huseyin Yer*
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Jon Mahoney
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Yi Li
University of Connecticut, Storrs, CT, USA

Euonymus alatus, also known as “burning bush” or “Winged Euonymus,” is an extremely popular landscape plant in the United States because of its brilliant red color in fall. However, burning bush is also highly invasive because of its prolific seed production and effective seed dispersal by birds. Hence, development of sterile, non-invasive burning bush is in high demand. We have used several approaches, including mutagenesis and tissue culture-mediated production of triploids, to create cultivars of sterile, non-invasive burning bush plants. We have observed that a number of triploid plant lines produced few fruits and seeds. Some of these sterile lines are also dwarf with reduced stem internode length. Further characterization show that pollen from some sterile lines is infertile. We have also produced several sterile plant lines of burning bush via mutagenesis. One mutant plant line has its flowers aborted at later stages due to non-viable pollen. Successful development of sterile, non-invasive cultivars of burning bush plants may help the ornamental industry and reduce seed-mediated undesirable spread of burning bush plants.

10:45 AM – 11:00 AM

Genetic Sterilization of Lantana camera to Produce Infertile, Non-invasive Cultivars

Zhanao Deng*
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Sandra B. Wilson
University of Florida, Gainesville, FL, USA

Gary Knox
University of Florida, Quincy, FL, USA

Rosanna Freyre
University of Florida, Gainesville, FL, USA

Lantana camara is an important nursery and landscape plant in many states including Florida. This species has been listed as an invasive species by the Florida Exotic Pest Plant Council and classified as invasive in Florida by the University of Florida/ Institute of Food and Agricultural Sciences (UF/IFAS) Assessment of Non-Native Plants in Florida’s Natural Areas. A research program was initiated in 2004 at the UF/IFAS’s Gulf Coast Research and Education Center to understand the reproductive
biography of *L. camara* and develop new infertile, non-invasive cultivars. Polyploidy, formation of unreduced female gametes, and production of apomictic seeds have been associated with the invasive potential of this species. Two infertile triploid cultivars (‘UF-T3’ and ‘UF-T4’) were released in 2011, followed by releasing of another two infertile triploid cultivars (Bloomify™ Red and Bloomify™ Rose) in 2016. Compared to ‘Pink Caprice’, a *L. camara* variety that is most close to the naturalized type, the pollen stainability of these new cultivars has been reduced by 85% or more, and fruit production has been reduced by greater than 99%. The new cultivars do not hybridize with the Florida native lantana species *L. depressa* or produce viable seeds after hand pollination. Based on the male and female fertility data of these cultivars and their lack of hybridization potential with *L. depressa*, the UF/IFAS Assessment of Non-native Plants in Florida’s Natural Areas concluded that these cultivars are not likely problematic taxa in Florida. Two of these cultivars, Bloomify™ Red and Bloomify™ Rose, became commercially available in spring 2018.

*Specified Source(s) of Funding:* USDA hatch projects (FLA-GCR-005065 and FLA-GCC-005507), USDA/TSTAR program, Southwest Florida Water Management District, Florida Department of Agriculture and Consumer Service (FDACS) Specialty Crop Block Grant program (Project #021747).

**International Horticultural Issues & Networking**

*Moderator:* Elizabeth Mitcham  
University of California, Davis, CA, USA

10:00 AM – 10:15 AM

**An In-country Assessment of the Apricot Supply Chain in Tajikistan**

Ariana Torres*  
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Peter Hirst  
Purdue University, West Lafayette, IN, USA

Klein Ileleji  
Purdue University, West Lafayette, IN, USA

Amanda J. Deering  
Purdue University, West Lafayette, IN, USA

Fruit drying can add value and decrease perishability of various fruits, including apricots. Dried apricots are an established agricultural product in northern Tajikistan (Sughd region), but a relatively new industry for southern Tajikistan (Khatlon region). The north has a more developed supply chain, characterized by established tree varieties, harvesting and drying protocols, and the existence of domestic and export markets. Advancing the dried apricot industry in southern areas is likely to increase income for small-scale farmers and promote economic and social development. We conducted a study to evaluate the market and technological factors involved in the production, harvest, and drying of apricots; as well as the potential barriers to the production of export-grade dried apricots by farmers in the Khatlon province. n June 2017, we conducted a baseline assessment of the apricot supply chain in north and south Tajikistan using surveys to farmers and interviews to apricot buyers, processors, and marketing cooperatives. Our results show that, regardless of the district and gender, southern farmers had lower yields and were less knowledgeable regarding harvesting, drying, and selling practices than their counterparts in the northern production areas. We also found they had fewer years of experience selling dried apricots, and apricots sales represented a lower proportion of the household income, when compared to northern farmers. All southern farmers correctly perceived that quality was the most important factor driving price premiums. Regardless of the gender and district, most farmers perceived they lack the knowledge and technology to produce dried apricots that meet market grade standards for export markets. This study provides a baseline assessment of the apricot supply chain in Tajikistan. Quality of dried apricots is a major barrier to market access and price premiums. Our data showed that fruit quality seems to be correlated with the lack of tree varieties suited for export markets, knowledge of drying technologies, and knowledge of export-grade market standards. The economic viability and livelihood of apricot farmers in Khatlon province could likely be improved by the introduction of adapted apricot varieties, insuring access to appropriate agronomic inputs and practices, strengthening postharvest and drying knowledge, introducing good food safety practices, and accelerating the farmers’ access to apricot buyers for export and domestic markets. Government, policymakers, researchers, and businesses can use our findings to assist farmers in developing new and maintaining existing market linkages.

*Specified Source(s) of Funding:* USAID, Feed the Future - Horticulture Innovation Lab

10:15 AM – 10:30 AM

**Empowering Turkish Women Farmers with Agricultural Business Management Training**

Robin Brumfield*  
Rutgers, The State University of New Jersey, New Brunswick, NJ, USA

Burhan Özkan  
Akdeniz University, Antalya, Turkey

Rabia Vezne  
Akdeniz University, Antalya, Turkey

Eda Ilbasın  
Akdeniz University, Antalya, Turkey

Farming is the principal economic activity in most rural areas of Turkey. Women represent a substantial share of the total agricultural labor force. Therefore, they need vocational training and guidance in their work places, but unfortunately, that was missing. The Empowering Women Farmers with Agricultural Business Management Training Project (EMWOFA) is a comprehensive training program for women farmers developed so that women farmers can develop technical, entrepreneurial and managerial skills. Turkish extension educators trained the first
A group of 34 women in Kozagacı village in Turkey last year using materials developed by EMWOFA. First, we trained extension educators using a teachers’ manual called the EMWOFA Educational program. The extension educators trained the women farmers using a workbook designed to help women farmers develop a business plan for their farms and review best management production methods for growing horticultural crops. The women could access E-learning videos that summarized the curriculum in the educational program and workbook on the EMWOFA website. Seventy percent of these women were the sole owner of their farming business, and their average age was 32.1 with an average 12.7 years farming. The greenhouse vegetables that they produced included tomatoes, cucumbers, lettuce and beans. Over eighty percent of the women felt that the business management and technical production sections of the program were valuable or very valuable. Nearly half of the participants selected management as the most useful part of the course. The majority of them plan to make changes in their production and management components of their business because of attending the program. Over 75% plan to keep better records after participating in EMWOFA training.

Specified Source(s) of Funding: Funded by the Erasmus+ Program of the European Union

10:30 AM – 10:45 AM

A Train-the-Trainer Program to Empower Women Farmers

Burhan Özkan
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Robin Brumfield*
Rutgers, The State University of New Jersey, New Brunswick, NJ, USA

Rabia Vezne
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The “Empowering Women Farmers with Agricultural Business Management Training” (EMWOFA) is an European Union (EU) Erasmus+ funded project to extend empower small-scale women farmers to manage their farms as businesses. It provides a comprehensive educational program to develop technical, entrepreneurial and managerial knowledge of extension educators in agriculture. These trained extension educators will train women farmers who are not likely to have vocational education training about the technical and managerial aspects of managing their farms. However, these women must work on farms. The EMWOFA Project developed educational materials to “Train the Trainers”. These educators will then train women farmers to improve their business skills and farms. This will have a multiplier effect by reaching women farmers in the EU and other countries. A teacher’s workbook or educational program gave the trainers educational material to train women farmers. We designed a workbook to help women farmers develop a business plan for their farms and review best management production methods for growing horticultural crops. Short, e-learning videos summarize the educational program and workbook. The videos are tagged one after another to make it easy for the user to follow.

The educational program, workbooks, and e-learning videos are available in four languages: Turkish, English, German, and Spanish. We shared the videos, educational program manuals, and workbooks for women farmers with extension bodies in the EU and posted them on the EMWOFA web portal for free use. We conducted a survey of 13 extension educators from Turkey and Germany who attended the first EMWOFA Train-the-Trainer session in Freising, Germany in Oct. 2016. The average age of the participants was 39 with an average of 9 years of experience as an extension educator. They all had positive impressions about the Educational Program. They felt confident about their knowledge in business management and technical production topics and scored their ability to teach every part of a business management and greenhouse production an average of 4.5 on a 5-point scale. Training materials are on the EMWOFA website <www.emwofa.eu> to guarantee both dissemination and the sustainability of the EMWOFA project

Specified Source(s) of Funding: Funded by the Erasmus+ Program of the European Union

10:45 AM – 11:00 AM

Internationalizing Extension through Agricultural Volunteer Opportunities

E. Vanessa Campoverde*
University of Florida Extension, Miami-Dade County, Homestead, FL, USA

Norma Samuel
South Carolina State University, Orangeburg, SC, USA

Andrea Fión Góngora
Farmer-to-Farmer, Guatemala

Through international experience Extension educators learn desirable skills to meet clientele needs and professional expertise working with other cultures in local communities while addressing global issues. Although highly encouraged, some challenges do arise for agricultural and Extension educators seeking opportunities to participate in international assignments. The U.S. Agency for International Development (USAID) Farmer-to-Farmer (F2F) program provides technical assistance from U.S. volunteers to farmers, farmer groups, agribusinesses and other agriculture sector institutions in developing and transitional countries with the goal of promoting sustainable improvements in food security and agricultural processing, production and marketing. The purpose of this proposal is to provide a practical overview of an F2F international extension assignment. The following questions will be addressed in this talk: 1) What are the requirements to be selected as an international F2F volunteer? 2) What are the perceptions of a young Extension agent professional during a first assignment overseas regarding expertise scope, preparation, challenges and expenses? 3) What are the outcomes and benefits from the international experience? The F2F program recruits volunteers from all 50 United States and the District of Columbia. Volunteers usually have domestic careers, farms and agribusinesses or are retirees. The time frame for the assignment was a two-week period, and targeted small,
Oral Presentations

11:00 AM – 11:15 AM

**Preserving the Harvest with Horticulture Technologies in Emerging Economies**

Elizabeth Mitcham*
University of California, Davis, CA, USA

Angelos Deltsidis
University of California, Davis, CA, USA

Michael Reid
University of California, Davis, CA, USA

James Thompson
University of California, Davis, CA, USA

Erin McGuire
Horticulture Innovation Lab, Davis, CA, USA

Fruits and vegetables are critical components to healthy diets, providing important micronutrients from prenatal to adulthood. In many parts of the developing world, rural and peri-urban families eat a very limited diet focused on staple crops, and are frequently not able to consume adequate amounts of nutritious foods. In these countries, horticultural crops are consumed only during a short period due to inadequate cooling, handling and storage facilities, leading to high losses after harvest. Horticulture crops provide important income and business opportunities in emerging economies. However, fruits and vegetables are perishable crops forcing farming families to sell their products at harvest when quality is high, but market prices may be low. Furthermore, high perishability prevents nutrient-rich fruits and vegetables from being consumed throughout the year. Cooling is the most efficient way of delaying the spoilage of fresh fruits and vegetables by slowing their metabolic processes. CoolBot® regulated cold rooms, which operate with household type air conditioners, can be installed in rural areas to provide moderate cost cold storage. Drying fruits and vegetables can stabilize and allow for storage of products that have not been sold or consumed due to gluts in supply. In tropical or humid areas, the drying process can be challenging, with high rates of spoilage due to torrential rains and high air humidity. A UC Davis-invented solar dryer, which has a chimney attached on one end of the drying table, facilitates airflow and reduces drying times while improving the quality of the dried products. The UC Davis DryCard is an important tool to measure the dryness of products before they are stored. This simple, inexpensive tool allows farmers and storage operators to quickly test if products have been dried enough to prevent harmful molds and toxins from developing in the product, affecting family health and the market viability of the products. Once the product is tested and determined to need additional drying, Zeolite clay Drying Beads, developed by Rhino Research, can be used to finish the drying process. These can be used on any dried product that needs to be stored, including high-value vegetable seeds. Once fully dried, the product can be stored or packaged in moisture-tight containers/packages. The implementation, operation, quality impacts and economic feasibility of these four technologies will be discussed, with evidence from several emerging economies. Successful adoption of these technologies is expected to support household nutrition and foster inclusive economic development.

**Specified Source(s) of Funding:** USAID Farmer-to-Farmer

11:15 AM – 11:30 AM

**Low Cost Technologies to Increase Fruit and Vegetable Availability in Rural Bangladesh**

Angelos Deltsidis*
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Amrita Mukherjee
University of California, Davis, CA, USA

Mohd Rezaul Islam
University of California, Davis, CA, USA

Michael Reid
University of California, Davis, CA, USA

Elizabeth Mitcham
University of California, Davis, CA, USA

According to recent studies and despite the efforts of the government and international donors, the rural population of Bangladesh suffers from chronic malnutrition. Climate change results in longer cyclone seasons and erratic weather that reduce the capacity of local population to secure year round availability of nutritious crops. It has been shown that horticultural crops can provide the necessary micronutrients for a healthy lifestyle. The lack of accessible, low cost methods to maintain produce quality after harvest along with the high prices of imported produce further reduce off-season consumption of fresh horticultural crops. A number of previously-tested, low cost technologies have been implemented in selected locations in southern Bangladesh. These technologies aim to reduce food losses and extend the availability of nutritious foods while they support the incomes of smallholder farmers and entrepreneurs. Cooling is the most important method of food loss reduction, but is out of reach for most smallholder farmers due to high setup and running costs. The Horticulture Innovation Lab has installed 12 low cost CoolBot-operated cold rooms that act as local, short-term cold storage points. In addition, data is being collected remotely on usage, power availability, and temperature settings, along with a high tech alarm notification system called ColdTrace. Drying is a popular preservation technique in Bangladesh which often produces lower quality or contaminated products due to high
humidity levels. Our team has installed innovative University of California Davis (UC Davis)-invented solar dryers, which facilitate airflow and reduce drying times while improving the quality of dried products. Seasonal flooding and expansion of aquaculture reduce the availability of suitable locations for family gardens which provide safe and nutritious vegetables and herbs. A bamboo raft was designed to hold soilless media for vegetable production, and these are floated in the sunny part of fishponds. This technology can combat food insecurity when water levels in the region rise by providing small plant-growing platforms that can be used even during the rainy season. Our team gathers an extensive number of data points including inputs and outputs to extrapolate the profitability prerequisites and potentials for each technology using a UC Davis-developed model. Based on the preliminary data of this ongoing study, the implementation, operation and scaling of the above technologies supports household nutrition, adequate quality and quantity of food intake, and can potentially reduce illness while supporting inclusive economic development.

**Specified Source(s) of Funding:** USAID

### Oral Presentations

#### Organic Horticulture 1

**Moderator:** Bodh R. Paudel  
University of Florida, Gainesville, FL, USA

10:00 AM – 10:15 AM

**A Pilot Study of Using Sunn Hemp Biomass for Anaerobic Soil Disinfestation in Organic Pac Choi Production**

Bodh R. Paudel*  
University of Florida, Gainesville, FL, USA  
Xin Zhao  
University of Florida, Gainesville, FL, USA  
Zack Black  
University of Florida, Gainesville, FL, USA  
Francesco Di Gioia  
University of Florida, Gainesville, FL, USA  
Jason C. Hong  
USDA-ARS, Fort Pierce, FL, USA  
Cristina Pisani  
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Erin N. Rosskopf  
USDA-ARS, Fort Pierce, FL, USA

Anaerobic soil disinfestation (ASD), based upon supplying a labile carbon (C) source, tarping, and watering the soil to field capacity to achieve soil anaerobic conditions, has shown to be a promising strategy for controlling soil-borne plant pathogens and parasitic nematodes and to improve vegetable production. To test the effectiveness of a summer leguminous cover crop, sunn hemp, as a potential carbon source for ASD, a pilot study of organic pac choi production was conducted at the University of Florida Plant Science Research and Education Unit in Citra, FL during Fall 2017. Summer-planted sunn hemp was used as the carbon source for ASD treatment using two approaches: terminated and incorporated into the soil in situ (SHi) versus aboveground biomass harvested and transported off site for soil incorporation (SH). In addition, composted poultry litter (CPL) was incorporated with sunn hemp (SH+CPL) or without (SH) in the ASD treatments. A standard ASD treatment with molasses and CPL and an untreated control (UTC) were also included. The raised beds for pac choi planting were irrigated to saturation and covered with black totally impermeable film (TIF) to initiate a three-week ASD treatment beginning 19 Oct. 2017. Twenty-four-day-old pac choi seedlings were transplanted on 13 Nov. and the mature heads were harvested 38 days after planting. Two field trials each using a completely randomized design with four replications were conducted simultaneously. In trial 1, SHI+CPL, SHT, SHT+CPL, and the standard ASD had significantly greater yields than SHI and UTC. In trial 2, treatments that utilized CPL resulted in higher yields than treatments that included only the cover crop and UTC. Interestingly, yellow nutsedge, the predominant weed in the beds and planting holes, grew in significantly higher numbers in SHI+CPL compared to UTC and other treatments in trial 1, while both SHI and SHI+CPL had significantly greater nutsedge counts than UTC and other treatments in trial 2. The crop yield discrepancy between the two trials might have resulted from the different levels of weed pressure present in the field. Nevertheless, the potential of using sunn hemp biomass as a carbon source for ASD treatment deserves more in-depth studies, together with analysis of the contribution of sunn hemp to soil fertility and quality.

**Specified Source(s) of Funding:** USDA-ARS

10:15 AM – 10:30 AM

**Assessing the Influence of Microbe-containing Crop Biostimulants on Vegetable Crops and Farms through On-station and On-farm Study**

Nicole Wright  
The Ohio State University, Wooster, OH, USA  
Stephanie Short  
The Ohio State University, Wooster, USA  
Julie Laudick  
The Ohio State University-OARDC, Wooster, OH, USA  
Zheng Wang  
The Ohio State University-OARDC, Wooster, OH, USA  
Subbu Kumarappan  
The Ohio State University-ATI, Wooster, USA  
Matthew Kleinhenz*  
The Ohio State University-OARDC, Wooster, OH, USA

Commercial microbe-containing crop biostimulants are advertised to maintain or enhance crop growth, perhaps especially under sub-optimal conditions (e.g., drought, nutrient deficiency, high temperature). More than two-hundred such products ranging in composition (e.g., bacterial, fungal, both; cfu/ml) are currently available, complicating product selection. Regardless, to be effec-
An asterisk (*) following a name indicates the presenting author.

S108

Oral Presentations

An asterisk (*) following a name indicates the presenting author.

S108

Soil Balancing Effects on Specialty Crops and Their Soils, Weeds, Farms, and Growers

Sonia Walker
The Ohio State University-OARDC, Wooster, OH, USA

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Opinions on the “soil balancing” philosophy of soil management among growers and private- and public-sector grower advisors and researchers range wide and, so far, rarely achieve consensus. Proponents, including increasing numbers of specialty crop growers (many sustainable-organic) and some advisors, report that soil chemistry—specifically, percentages and ratios of calcium, magnesium, and potassium—can be altered through applications of lime, gypsum, and other materials to improve soil physics (tilth) and biology and, thereby, crop yield and quality and weed control. Investigators and other advisors, however, report that soil balancing claims are unsupported by the data (at minimum) and potentially injurious to farms (at worst). That disconnect is both a problematic trend and important opportunity. As part of a larger effort to understand the use and outcomes of soil balancing as practitioners do while also providing needed data, eight certified-organic main plots (17.1 m × 18.3 m) were established in 2015–18 at the OSU-OARDC in Wooster, OH. Main plots contained two (17.1 m × 9.1 m) subplots based on their having received an annual application of composted dairy manure every year since 2003 or no compost application. Three (5.3 m × 9.1 m) sub-subplots/subplot were created on June 11, 2015 by applying one of three soil amendment treatments: 1) gypsum (1681.5 kg·ha−1), 2) potassium sulfate (560.5 kg·ha−1), and 3) gypsum + potassium sulfate (same rates). Rock phosphate was also applied at 560.5 kg·ha−1 to minus-compost subplots. Treatment applications were repeated at the same locations each mid-May 2016–18. Sub-subplots were direct seeded with four rows of both edamame soybean and dwarf popcorn on 12 June 2015, 25 May 2016, and 23 May 2017, with edamame being reseeded on 21 June 2016 and 14 June 2017. Two rows of butternut squash were also direct-seeded into each sub-subplot on 18 June 2015, 31 May 32016, and 26 May 2017. All crops received multiple applications of fish fertilizer (analysis of 2–4–1) each season either by hand (edamame, popcorn) or via fertigation (squash). Percent stand, above-ground canopy development, mass of mature leaves at the onset of reproductive growth, and crop yield (total, marketable) and quality were recorded each season either by hand (edamame, popcorn) or via fertigation (squash). Percent stand, above-ground canopy development, mass of mature leaves at the onset of reproductive growth, and crop yield (total, marketable) and quality were recorded each year along with measures of soil macro- and micronutrient levels. Treatments have resulted in few significant differences in either plant growth, or crop yield or quality to date. Weed seedbank analysis and comprehensive assessments of grower attitudes and farm economics are also underway.

Specified Source(s) of Funding: USDA ORG, USDA NCR-SARE, Warner Foundation, The OSU

10:30 AM – 10:45 AM

HortScience 53(9) Supplement—2018 ASHS Annual Conference
Plants respond to pest attack by triggering several changes in biochemical contents namely primary and secondary metabolites. Phenolic acids are organic compounds that influence pest behavior, feeding efficiency and could limit herbivore damage based on their activity as feeding deterrents. These organic compounds play a role in indirect plant defense by attracting natural enemies and may vary with management systems used for production of organic vegetables. A research project was conducted with a goal to link phytochemicals to striped cucumber beetle (SCB) population and parasitism when organic cucumber plants were grown in rolled-crimped cover crop plots and compared to those in plastic mulch with and without insectary strips. Results showed that SCB populations in 2017 were much lower compared to 2016 and was slightly greater, although not significantly, in plastic compared to rolled mulch. Proportion of SCB parasitism by tachinid fly was slightly greater in plastic than in mulch but did not differ between insectary and no insectary treatments as anticipated. Concentration of rosmarinic acid and syringic acid were significantly greater in leaves of cucumber plants grown in plastic mulch than in rolled mulch. Syringic acid is known to attract parasitoids. However, ferulic and p-coumaric acids were significantly greater in cucumber plants grown in rolled mulch systems. These latter compounds were documented to serve as feeding-deterrent for certain pest insects and could explain the lower level of SCB density and parasitism in rolled mulch treatment. There was no direct and measurable effect of presence or absence of insectary strips on SCB density, parasitism, and concentrations of polyphenols in cucumber plants. However, this tactic was found to enhance densities of ground beetle and wolf spiders (other ground natural enemies to SCB). This multi-tactic approach could serve as a potential biocontrol management system for attracting insects and controlling SCB.

Specified Source(s) of Funding: Frontier Natural Products Co-op and Pennsylvania Department of Agriculture
Extending the storage period of winter squash did not impact stored fruit quality even after 60 days. Organic winter squash growers may reap additional revenues by offering community supported agriculture’s (CSA) members nutritious and healthy fruits during fall season.

Specified Source(s) of Funding: NE-SARE ONE 17-307

11:15 AM – 11:30 AM

Evaluation of Eight Organic Cucumber Cultivars in a High Tunnel with Insect Screens
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John Kimes
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Cucumber (Cucumis sativus) is one of the most popular vegetable species in high tunnels. English and Beit Alpha cucumber are well suited to the enclosed high tunnel environment because they are often parthenocarpic and gynocious, have better taste, and are very productive. However, most English and Beit Alpha cucumber cultivars have not been tested in high tunnels. These cultivars are also intolerant to bacterial wilt disease transmitted by cucumber beetles. The objective of this trial was to evaluate the yield potential of English and Beit Alpha cucumber cultivars in high tunnels with insect screens. Eight organic cucumber cultivars (Corinto, Diva, Kalunga, Katrina, Picolino, Socrates, Tasty Jade, and Tyria) were tested in an organic high tunnel (30’W x 96’L) in Greensboro NC (hardiness zone 7) from Apr. to Sept. 2017. The experiment was conducted as a completely randomized design with four replications. There were six vines per replication. Insect netting (mesh size of 0.0138” x 0.0138”) was installed on both side-walls of the high tunnel. Cucumbers were trained to one leader per vine and trellised with the Tomato Roller Hooks system. All cultivars grew vigorously. The length of a vine was 15–26 feet long at the end of season, with ‘Socrates’ and ‘Corintoa’ having more than 100 nodes on a vine. The insect netting blocked cucumber beetles and other insect pests. There were significant differences among cultivars in terms of yield and number of fruit per vine. The marketable yield and number of fruit ranged from 8.9 lb and 21.3 fruit per vine for ‘Diva’ to 20 lb and 53.3 fruit per vine for ‘Socrates’. ‘Socrates’ had the consistently highest yield throughout the season, followed by ‘Corintoa’, ‘Picolino’ and ‘Tasty Jade’. Most cultivars had their first fruit at node three. On average there was one fruit per vine to two four nodes on a vine depending on cultivars. The °Brix ranged from 3.1 for ‘Katrina’ to 4.7 for ‘Diva’. In conclusion, insect screen totally controlled cucumber beetles. English or Beit Alpha cucumbers are good options for high tunnel production. ‘Socrates’ and ‘Tasty Jade’ were the most productive, ‘Kalunga’ and ‘Tyria’ were medium productive but with the longest fruit, and ‘Diva’ was not an ideal cultivar for high tunnel production.

An asterisk (*) following a name indicates the presenting author.
This is because the majority of recycled water cost is attributed to the large capital cost for the recycled water system. Due to its potential cost savings, recycled irrigation runoff water is a viable alternative to many high-cost water sources and public funding can help further reduce the cost of recycled water for growers of containerized plants.

**Specific Source(s) of Funding:** USDA-NIFA-SCRI # 2014-51181-22372

10:30 AM – 10:45 AM

**Tools for Growers to Assess Disease Risk**

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University of California, Davis, CA, USA  
John Majsztrik*  
Clemson University, Pendleton, SC, USA

Plant disease management is an integral part of ornamental plant production. Nurseries and greenhouse operations typically take certain actions to limit disease incidence and spread, but they may be unsure which practices would be the most effective or have the lowest cost to implement. A system-based approach considers the whole operation to identify situations or practices that are most likely to spread plant diseases. There are printed assessments that growers could use to better understand practices that increase or decrease their risk of cultivating plant diseases at their operation. These written tools can be cumbersome, require specialized knowledge to complete, and are not linked to additional educational resources. To address these challenges, we developed a new online decision-support tool which prioritizes the most important disease hazards, so users can determine where to invest limited resources to have the greatest impact. The online tool also allows the user to select only those practices that are relevant to them (i.e. greenhouse production but not field production). The user receives immediate feedback to identify disease hazards associated with their current practices, and suggestions for corrective actions. Links to additional resources are provided. This decision-support tool should decrease disease losses and increase profitability over time, for growers who are willing to make the necessary changes in their production practices.

**Specific Source(s) of Funding:** USDA-NIFA-SCRI # 2014-51181-22372

10:45 AM – 11:00 AM

**Coordinating Water Quality Outreach to Best Reach Your Audience**

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A feature of irrigation water quality and conservation topics is the breadth of issues that horticulture growers face, each requiring specific recommendations. This diversity in water issues creates an opportunity and challenge for education. One approach we have taken is to develop detailed and representative case studies, for example a southern California nursery where water conservation practices were detailed and a positive economic return could be shown on investment in equipment for runoff capture and treatment. The CleanWater3.org website has research report components typical of grant projects, but we have maximized impact of publications and presentations with a biweekly posting of new research outputs in an email newsletter using Mailchimp™, in addition to Facebook™ updates. Other notable features of CleanWater3.org include a modern tile appearance whereby each site visit cycles through a different set of highlighted solutions to water-related issues; an “Ask the Expert” function where questions are routed to the grant team and are turned into frequently-asked-question topics; and a training section that features upcoming face-to-face and online workshops. Interactive decision-support tools include Waterborne Solutions, which is a searchable database of research on efficacy of sanitizing technologies against plant pathogens; a WaterQC tool to interpret water test results such as ion levels and turbidity; and GroZone Tracker for organizing onsite monitoring soil testing data. With this social media and website presence, in 2018 we reached 2075 users per month.

**Specific Source(s) of Funding:** USDA-NIFA-SCRI # 2014-51181-22372

11:15 AM – 11:30 AM

**Water Security and Life Cycle Assessment—Impact of Water Recycling**

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Texas A&M University, College Station, TX, USA  
Joshua Knight  
University of Kentucky, Lexington, KY, USA

Life cycle assessment (LCA) is a research tool for systematically evaluating the inputs and processes in a product’s life cycle relative to potential environmental impacts. LCA has been used to analyze the production systems for trees, shrubs, flowering annuals and potted flowering crops, focusing on global warming potential and water consumption. Information from these analyses have been used to calculate water consumption and water footprints (WF) for these products using international standards relying on monthly water scarcity index for specific locations. The calculation of water scarcity has evolved over
the last decade from a simple ratio of withdrawal-to-availability (WTA) in 2006 to the current method recommended for characterizing water use in life cycle assessment (WULCA) to a ratio relative to a global average of available water remaining (AWARE) in 2016. Consumptive use in a location includes water used or degraded by human populations and our activities as well as water requirements to maintain ecosystems. The consumptive use portion of this equation for nursery and floriculture crops can be modified by increased irrigation efficiency, the capture, storage and recycling runoff water, and remediation of any potential contaminants in water discharged from the nursery or greenhouse site. Data will be presented to show the potential impact of such practices studied and proposed by the Clean WateR3 team on the model systems studied using LCA.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-22372

Ornamental Plant Breeding 1

Moderator: Ellen L. Young
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10:15 AM – 10:30 AM

Photoperiod Effects on Flowering and Propagate Production in Gladiolus Hybrids

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University of Minnesota, St. Paul, MN, USA

Photoperiod is flowering inductive for many species, along with other influential parameters. Cultivated gladiolus, Gladiolus xgrandiflorus, a geophytic species producing corms, is known to be a long day plant. New seed-propagated gladiolus hybrids have been developed although the interaction and influence of photoperiod on asexual propagules (cormel, corm production) is unknown and poorly understood in commercial hybrids. In this research our objective was to study the influence of photoperiod on flowering and foliage height, number of leaves, and asexual propagule production (corm weight, number of cormels, and weight). Clonal replications of three new seed-propagated gladiolus breeding lines of the University of Minnesota and a geophytic species producing corms, is known to be a long day plant. New seed-propagated gladiolus hybrids have been developed although the interaction and influence of photoperiod on asexual propagules (cormel, corm production) is unknown and poorly understood in commercial hybrids. In this research our objective was to study the influence of photoperiod on flowering and foliage height, number of leaves, and asexual propagule production (corm weight, number of cormels, and weight). Clonal replications of three new seed-propagated gladiolus breeding lines of the University of Minnesota and ‘Galmini’, a commercial cultivar comparison, were tested in both long and short day treatments. Short days inhibited flower bud initiation and development, but also significantly reduced foliage height, the number of leaves, corm weight, number of cormels and weight by treatment and genotype. The short day treatment negatively influenced gladiolus overall performance in growth and development.

Specified Source(s) of Funding: Kuwait University and the MN Agricultural Experiment Station

10:30 AM – 10:45 AM

Direct Organogenesi and Bulblet Regeneration of a Wild Bulbous Flower Lycoris Sprengeri

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Lycoris is a bulbous plant of high medicinal, ornamental and ecological value; mainly distributed in East and South Asia. Lycoris has attracted the attention of synthetic organic chemists for their alkaloids that exhibit immunostimulatory, anti-tumor, anti-viral, and anti-malarial properties. Also, due to its distinctive flowers, Lycoris is a popular ground cover and cut flower crop. However, commercial Lycoris production and breeding have been hindered by its extended juvenile period and low regeneration rate under natural conditions. To date, no efficient regeneration system in Lycoris is available and the massive exploitation of bulbs has already caused considerable damage to wild resources and their natural habitats. In vitro propagation using different explants, including twin scales, multi scales, and floral organs, had limited success. One factor hampering successful micropropagation of Lycoris might be the extremely high contamination rate. Another factor might be the difficulty in obtaining optimal explants since the accumulation and oxidation of phenolic compounds in mature tissues results in tissue browning and inhibited cell division. Here we established a bulblet regeneration system through direct organogenesis from the in vitro-derived protrubles of Lycoris sprengeri. The highest frequency (95.5 ± 3.2%) of direct organogenesis was obtained on medium supplemented with 6.0 mg L⁻¹ 6-benzyladenine (6-BA) and 1.0 mg L⁻¹ α-naphthaleneacetic acid (NAA), of which a mean of 36.3 ± 6.8 regenerated bulblets per explant were obtained after six weeks of culture. Histological studies at different developmental stages revealed the mode of direct organogenesis from the protrubles. An increasing amount of cytoplasmically dense cells were observed to rapidly form adventitious meristems, which later gave rise to multiple shoot buds, suggesting direct organogenesis for bulblet regeneration via this system. The optimal medium for rooting was MS medium with 1.0 mg L⁻¹ NAA and 60 g L⁻¹ sucrose. More than 98% of rooted bulblets survived after acclimation. Based on the establishment of this bulblet regeneration system, multiple genetically identical clones can be generated from a single seed-derived protruble in a relatively shortened breeding cycle (approximately 20 weeks).

Specified Source(s) of Funding: New Agricultural Variety Breeding of Zhejiang Province, Project NO. 2016C02056-13
10:45 AM – 11:00 AM

**Synthesis and Cleavage of Carotenoids Contributed to the Color Difference between Chinese Narcissus and Its Yellow-tepal Mutant**

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Donglin Zhang  
University of Georgia, Athens, GA, USA

Chinese narcissus (Narcissus tazetta var. chinensis) was introduced 1300–1400 years ago and naturalized in coastal areas and offshore islands of southeastern China. It is one of popular Chinese traditional indoor flowers and famous flowering bulbs in the world with only two white-tepal triploid cultivars, ‘Jinzhan Yintai’ and ‘Yulinglong’. Recently, a yellow tepal mutant was discovered and gained popularity quickly. We conducted pigment metabolite analysis and comparative transcriptome profile for ‘Jinzhan Yintai’ and the mutant. The tepal epidermis of the mutant had much more and larger chromoplasts than those of ‘Jinzhan Yintai’. Ultraviolet-visible spectroscopy concluded that total flavonoids and carotenoids were semi-quantified in five flowering stages, from green-tepal to semi-perish stage. Although no significant difference between the mutant and ‘Jinzhan Yintai’, when quantitative determination of total flavonoid content, the total carotenoids of the mutant were more than 10-fold higher. Using comparative KEGG pathway enrichment analysis, carotenoid related pathways in the two cultivars showed significant variations. The structure of carotenoids biosynthetic pathway in both cultivars was completed and DXS and GGPS genes expressed even higher in white narcissus. The downstream PSY and NCED genes, which played the essential roles in synthesis and cleavage of carotenoids respectively, were found to express in an opposite way. In white narcissus, the expression of PSY was decreased, while NCED genes in carotenoids degradation sub-pathway was increased. In mutant, though PSY, ZDS, LCY, even NCED were accumulated along with the flower open process, PSY displayed up-regulated expression and NCED down regulated remarkably when compared to the transcriptome of ‘Jinzhan Yintai’. Therefore, adequate color pigments synthesized from carotenoids metabolic pathway in chromoplasts of the mutant tepals were not degraded, which led to the color differentiation.

*Specified Source(s) of Funding:* The Science and Technology Project of Zhangzhou

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11:00 AM – 11:15 AM

**Screening of Rose Varieties for Rose Rosette Virus Resistance in Texas**

Madalyn Shires*  
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Kevin Ong  
Texas A&M AgriLife Extension Service, College Station, TX, USA  
David Byrne  
Texas A&M University, College Station, TX, USA

Genetic resistance to diseases is an ideal trait to have in plants. One crop where resistance is needed is in roses. This is because of a viral disease that is decimating the rose industry. The *Rose Rosette Virus* (RRV) causes the disease known as Rose Rosette Disease. This virus is vectored by a microscopic Eriophyid mite, *Phyllocoptes fructiphilus*. This mite feeds on roses and females overwinter on the rose plant. There is research that suggests the mite can be controlled with miticides, however treatment only prevents infection if started before mites feed on plants. Unfortunately, once the rose is infected, there is no cure. Thus, the management approach is to eliminate infected plants to avoid disease spread. Efforts to identify resistance in a rose variety have been ongoing for four years. As of now, no resistant variety has been confirmed, however through ongoing screening activities, it is hoped that a resistant variety will be identified. Over the last three years, field trials have been established in various parts of Texas to screen rose varieties. The plots were located in Wichita Falls (2 years), Dallas (Year 3), Farmers Branch (Year 2), Denton (Year 2), Cleburne (Year 2), and Dallas-Coit Rd. (Year 1). Approximately 160 rose varieties have been screened or are being screened through these plots. We have identified three roses (‘Bayse’s Purple’, ‘Chuckles’, and ‘Caldwell Pink’) that appear tolerant to the disease. These varieties have tested positive for the virus (plants from Wichita Falls plot), but through the three years of screening have not developed symptoms. There is also one rose, ‘Lafter’, which is being screened in seven locations across the United States that has not yet shown symptoms.

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11:15 AM – 11:30 AM

**Rapid Phenotyping for Rose Breeding**

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Shenyang Agricultural University, Shenyang, China  
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Univ. Nebraska–Lincoln, Lincoln, NE, USA  
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Texas A&M University, College Station, TX, USA  
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Texas A&M University, College Station, TX, USA  
Stella Kang  
Texas A&M University, College Station, TX, USA

One crop where resistance is needed is in roses. This is because of a viral disease that is decimating the rose industry. The *Rose Rosette Virus* (RRV) causes the disease known as Rose Rosette Disease. This virus is vectored by a microscopic Eriophyid mite, *Phyllocoptes fructiphilus*. This mite feeds on roses and females overwinter on the rose plant. There is research that suggests the mite can be controlled with miticides, however treatment only prevents infection if started before mites feed on plants. Unfortunately, once the rose is infected, there is no cure. Thus, the management approach is to eliminate infected plants to avoid disease spread. Efforts to identify resistance in a rose variety have been ongoing for four years. As of now, no resistant variety has been confirmed, however through ongoing screening activities, it is hoped that a resistant variety will be identified. Over the last three years, field trials have been established in various parts of Texas to screen rose varieties. The plots were located in Wichita Falls (2 years), Dallas (Year 3), Farmers Branch (Year 2), Denton (Year 2), Cleburne (Year 2), and Dallas-Coit Rd. (Year 1). Approximately 160 rose varieties have been screened or are being screened through these plots. We have identified three roses (‘Bayse’s Purple’, ‘Chuckles’, and ‘Caldwell Pink’) that appear tolerant to the disease. These varieties have tested positive for the virus (plants from Wichita Falls plot), but through the three years of screening have not developed symptoms. There is also one rose, ‘Lafter’, which is being screened in seven locations across the United States that has not yet shown symptoms.
Ornamental cultivars need to be attractive throughout the growing season so there is a need for repeated evaluations on a range of ornamental and adaptation traits. Essential traits would be growth rate, flower productivity, flower size, flower color, leaf density, and disease resistance. Traditionally breeders evaluate their materials 2–3 times per year that results in an incomplete picture of the plant performance. In 2016, selected rose genotypes in a rose variety trial were photographed using with a tablet with a camera mounted on a selfie stick to obtain an overhead picture (2 m height) of the plant. In 2017, the entire field was photographed using an octocopter with a RGB camera at an altitude of 18 m. Concurrently the plots were evaluated on a monthly basis for flower intensity, defoliation, black spot incidence, cercospora incidence and landscape quality. The calculation of flower intensity of the digital images correlated well with the visual ratings of flower intensity. Using this approach, the rose plants were assessed for their ability to produce flowers through the year.

Specified Source(s) of Funding: NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

Marketing and Economics

Moderator: Julie Campbell
University of Georgia, Athens, GA, USA

10:15 AM – 10:30 AM

Consumer Preferences and Willingness-to-pay for Rose Attributes

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Marco Palma
Texas A&M University, College Station, USA

David Byrne*
Texas A&M University, College Station, TX, USA

Discrete Choice Experiments (DCE) are used to investigate consumer preferences and willingness-to-pay for roses. DCE is a technique for measuring buyers' tradeoffs among multiple attributes of products and services. It has been widely used in the field of marketing research to determine consumer’s preferences for products. It is based on the simple premise that consumers evaluate the overall value of a product, service, or idea by combining the separate amounts of value provided by each product attribute. In this DCE the evaluated features include price, disease tolerance, heat resistance, drought resistance, bloom size, and leaf coverage on perceptions, liking and willingness-to-pay for rose characteristics. With price ranging from $10 to $25 and relative to the average price of about $12.70, large blooms generated price premiums of $4.40. Tolerance to disease, heat, and drought resulted in $12.80, $13.20, and $8.50 premiums, respectively. Full leaf coverage resulted in a $5.00 premium. While these were the average premiums, there was some heterogeneity in willingness-to-pay for all the product attributes. Eye-tracking was used to reveal visual attention to the rose attributes. The eye-tracking data is used to complement the choice data for attribute attendance in order to obtain more accurate measures of willingness to pay.

Specified Source(s) of Funding: NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

10:30 AM – 10:45 AM


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Bridget Behe
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The strain on potable water supplies heightens the competition for water resources and potentially reduces demand for outdoor plantings and landscaping. Approximately 35% of domestic potable water is used for irrigation, 45% is used for thermoelectric production, but only 9% for public potable water supplies. Lifestyle influences water use. For individuals with high aesthetic and recreational priorities, outdoor water use is high. Recent research suggests attitudes toward the uses of potable water supplies have changed in other countries due to greater social awareness and increasingly widespread exposure to drought conditions. Education about and adoption of sustainable water use practices may help ensure an adequate supply of irrigation water while conserving water sources for human and ecosystem services. Other research suggests that consumers are willing to pay more for plants grown using more environmentally-friendly practices, including water conservation in plant production. We hypothesized that water conservation involvement and expertise may be negatively related to plant expertise and involvement and the importance of landscaping since individuals with high aesthetic and recreational priorities, use more water outdoors. We conducted an online survey with 1543 respondents in 2016 to ascertain their water conservation and plant expertise and involvement, horticultural importance, and demographic characteristics using a principal component
analysis with orthogonal rotation which is used to describe the strength and direction of correlated variables in terms of their potential to quantify unobservable constructs. We then took the component results and conducted a K-means cluster analysis to find groupings in the data. Cluster analysis results identified two key market segments comprising ~50% of the sample each: those who are Actively Interested in Water Conservation and those who are Passively Disinterested in Water Conservation. Results show the Actively Interested Cluster segment spent almost twice as much as the Passively Disinterested segment in spending on plants and related supplies excluding equipment in 2015 and 2016. The Actively Interested in Water Conservation segment also purchased more annuals, vegetable transplants, herb transplants, perennials, flowering shrubs, evergreen shrubs, fruit producing trees, evergreen trees and shade trees in 2016. Findings suggest that pro-water conserving attitudes are found among consumers who value outdoor landscapes and those individuals who spent more on plants. Results suggest that producers and retailers should focus marketing and communication efforts on low-water use cultivar selection and operationalizing water conserving behaviors more than convincing consumers that plant purchases and landscaping are important.

Specified Source(s) of Funding: USDA SCRI Clean WaterR3 – Reduce, Remediate, Grant Number 2014-51181-22372; USDA NIFA Hatch Projects MICL 02085 and 02473, and TEX0-1-7051; Michigan State University AgBioResearch, and MSU Project GREEN and Texas A&M AgriLife Research

10:45 AM – 11:00 AM

Reasons for Use and Non-use of Farmer’s Markets and Roadside Stands

Julie Campbell*
University of Georgia, Athens, GA, USA

The state of Connecticut is one of the most progressive states with respect to the local food movement. As such, there are numerous farmer’s markets located throughout the state. However, many consumers still do not frequent farmer’s markets to buy their goods, mainly produce. Using results from an online survey of around 850 consumers within Connecticut, we examine Connecticut consumer use and non-use of farmer’s markets. Specifically, we examine the reasons why consumers shop at a farmer’s market as well as the barriers for lack of shopping at a farmer’s market. Our results indicate that 85% of consumers frequenting a farmer’s market travel 20 minutes or less to shop at the market. The top two reasons why they shop farmers markets is for product freshness and the availability to buy local produce. With respect to non-users, 71% live less than 20 minutes from a farmer’s market. However, respondents cited distance to the farmer’s market and high prices as the main barriers for shopping at the market. Based on these and other findings, we make recommendations for farmer’s market retailers and policy makers to increase farmer’s market use.

An asterisk (*) following a name indicates the presenting author.

HortScience 53(9) Supplement—2018 ASHS Annual Conference
The North American Pawpaw Industry in the United States—Supply, Demand, Challenges, and Opportunities
Zhen Cai*
University of Missouri, Columbia, MO, USA
Michael A. Gold
University of Missouri, Columbia, MO, USA

The North American pawpaw (Asimina triloba) is a native specialty fruit crop that has been consumed seasonally by Native Americans for millennia. Conversely, pawpaw is largely unknown to the American consumer. This study aims to examine the current pawpaw industry in the United States using the Porter Five Forces Model. A questionnaire was sent to pawpaw value chain market participants in 2017. Responses from 81 market participants were collected including: pawpaw fruit harvesters, tree and fruit growers, value added producers, distributors, retailers and wholesalers. Results indicate that the emerging pawpaw market has great potential with respondents uniformly indicating that demand is likely to increase over the next five years. However, the supply of grafted pawpaw cultivars and fresh pawpaw fruit is limited and fresh fruits are not shelf stable. At present, there is little competition within the U.S. pawpaw industry, and pawpaw products have few substitutes. Lack of consumer awareness of pawpaws; short shelf life; unstable pawpaw product supply; lack of knowledge in growing, harvesting and marketing pawpaws; and strict shipping and food safety policies are potential barriers to entry that must be considered for potential and current producers to achieve success in the pawpaw industry.

Specified Source(s) of Funding: US Department of Agriculture: Agriculture Research Service

Assessing the Market Opportunities for Fruit and Vegetable Farmers: An Overview of Fresh Market Retailers’ Preferences
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The increasing demand for fresh fruit and vegetables offers important market opportunities to U.S. farmers. Increasing popularity of local and organic foods and the expansion of direct-to-consumer and new intermediate market outlets allow farmers to capture a higher share of the consumer dollar. Despite these economic opportunities, developing new market linkages is challenging for fruit and vegetable farmers; particularly in light of the seasonality and volatility of the fresh market industry (Klonsky et al., 2002). Moreover, it is unclear what are the main trends driving retailers’ purchases as supply shortages, contract work, and small procurements become commonplace in the fresh market industry. This study investigates fresh market retailers’ preferences and requirements with respect to their produce suppliers. Face-to-face interviews with fresh produce retailers in Indiana were conducted in 2014 and 2015 about their current retailing operation, the buying decision-making process, supplier attributes, supplier-buyer contracts, retailers’ perceptions, and the importance of organic, conventional, and local attributes for retailers. The article also draws from a growers’ survey to tackle on the marketing gaps between growers and buyers of fresh market fruit and vegetables. Results show that Indiana fresh market retailers source from a variety of suppliers ranging from local farmers to local and regional wholesalers. Large grocery chains source mainly from regional distributors and wholesalers, for which formal written contracts and specific packaging, labeling, delivery, and traceability are key suppliers’ attributes. Smaller retailers in urban and rural counties source mostly from local farmers where flexible sales arrangements, trust-based transactions, and supply reliability are important farmers’ attributes. While product pricing is an important supplier attribute, most retailers offer farmers price premiums for locally grown produce. Regardless of size or location, most retailers recognize the effect of television and internet on customer purchasing behavior. Large and small retailers reported the value of capturing consumers’ preferences for developing marketing strategies, but they tend to gather consumer demand differently. Large grocery chains capture consumer trends through inventory turnover and weekly sales, while small specialist retailers strive to know their customers, understand their needs, and encourage employees to answer customers’ questions. Increasing the marketing opportunities for local fruits and vegetable farmers is important to assure the sustainability of the specialty crop industry. This research shows that quality produce, affordable prices, and reliability are key attributes sought by retailers Policymakers, researchers, and extension agents can use these findings to assist farmers in developing new and maintaining existing market linkages.

Specified Source(s) of Funding: NIFA-OREI

Undergraduate Student Oral Competition
Moderator: Stephanie Burnett
University of Maine, Orono, ME, USA

Cultivar and Growing Media Affect Root Length and Number during Fall Olive Propagation in Oregon
Tessa A. Walker
Oregon State University, Corvallis, OR, USA
Oral Presentations

Heather Stoven
Oregon State University, McMinnville, OR, USA

Javier Fernandez-Salvador
Oregon State University, Corvallis, OR, USA

Tessa A Barker*
Oregon State University, Corvallis, OR, USA

Guayule is a desert-adapted woody perennial, having been used as a landscape plant and presently being commercialized for rubber production. It is difficult to establish guayule from seed, and an alternative method of propagation is by cuttings. Success in this process is dependent on multiple environmental and endogenous factors, including: humidity, media, age of cutting material, and hormone treatment. The factor manipulated in this study was auxin. The hypothesis was a low concentration of auxin would have minimal effect on rooting, and a high concentration would have a negative effect. A range of 500 ppm to 2000 ppm (in steps of 500 ppm) of Indole Butyric Acid (IBA) in solution with water were tested. The same range was applied with Napthaleneacetic Acid (NAA). Many commercial rooting hormone products mix of IBA and NAA, so one treatment of 750 ppm IBA:750 ppm NAA treatment was included. A DI water treatment was the control. The cutting material was late first-year growth from shoot tips, cut between 6-9 cm, and the bottom two-thirds stripped of foliage. The cuttings were treated in batches of 10; the basal cuts dipped into a treatment solution, agitated for 10 seconds, and allowed to soak for another 50 seconds. Cuttings were planted approximately 5 cm deep in a media of 1:1 coco coir and perlite. A total of 1,600 cuttings, for the 10 treatments, 4 varieties (AZ-3, R1100, 593 and 11693), and 4 reps were treated. Each repetition was fitted into two plug-trays, for a total of 400 cuttings. Each treatment was randomly assorted into a 2 × 5 cell region of the tray. After 46 days, the cuttings were scored: 0 = dead, 1 = no change, 2 = cell differentiation (but no rooting), 3 = root initiation, 4 = 1/3 of plug rooted, 5 = 2/3 of plug rooted, and 6 = fully rooted plug. Just considering total number rooted (rooting scores of 4, 5, and 6 combined), there were few differences among auxin treatments. That the treatments were generally not different from water, the auxin concentrations were neither high or nor low enough to confirm the hypothesis. There were significant differences among lines for treatments. Lines 593 and R1100 produced fewer roots in comparison to AZ-3 and 11693. The combination IBA:NAA treatment produced a higher number of rooting scores of 5 and 6. Thus, the experiment is continuing by testing different ratios of IBA:NAA, and varieties AZ-3 and 11693.

Specified Source(s) of Funding: College of Agriculture, Oregon State University, Corvallis, OR, USA

12:45 PM – 1:00 PM

Vegetative Propagation of Guayule

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Specified Source(s) of Funding: USDA-NIFA

1:00 PM – 1:15 PM

Organic Strawberry Transplant Production for Season Extension in Oregon: Effects of Container Size on Cost, Ease of Planting and Plant Development

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Javier Fernandez-Salvador
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Irrigation with water containing plant pathogens, such as species of oomycetes, has the potential to induce high levels of root and crown rot in plants. To test the prevalence of these pathogens in early January, the irrigation ponds of a group of local Maryland pick-your-own operations were sampled. These operations harvest a wide variety of crops, including strawberries, apples, pumpkins, and raspberries. Many of these specialty crops are known for being highly susceptible to oomycetes, which can cause heavy economic losses. Rhododendron leaves were used as a pathogen trap to sample the irrigation ponds for the presence of oomycetes. Once collected, the leaflets were plated and monitored for mycelial growth. Next, differential plating was used to segregate the groups of *Phytophthia* and *Phytophthora* cultures. The DNA was extracted from each of the samples and underwent a polymerase chain reaction (PCR). This allowed the samples to be tested using the Blast technique to identify the particular species and isolate of the samples collected. During the spring, the pathogenicity of these particular isolates was tested using strawberries and pumpkins. Each crop was inoculated with a different isolate of the pathogens in a growth chamber and their growth and general health were recorded. The positive results of the irrigation pond sampling during early January highlighted the resilience of these plant pathogens. These results demonstrate the opportunity for growers to screen their irrigation water for plant pathogens and then deploy preventative measures prior to the growing season.

1:30 PM – 1:45 PM

**Predictive Breeding: A Study of the Effectiveness of Tissue Storage Methods for Genome Analysis**

Jed Donald Grow*
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Understanding the genome size and ploidy level of the species and specimens in our beardtongue (*Penstemon* Mitch.) breeding program is essential to making appropriate crosses, and to assess the success of induced polyploid plants. Frequently in plants, flow cytometry (FCM) analysis is used to estimate the genome size of a specimen in question by comparing it with an internal standard of a known plant genome size. The FCM generally requires fresh tissue and uses a fluorescent dye to stain the nuclei of the cells, where they are then passed through a laser. The fluorescence of the DNA is measured and compared to the internal standard. Unfortunately, fresh tissue is not always available to immediately process for analysis. We have read in the literature that FCM has been used to identify the genome size of well preserved herbarium samples. We hypothesized...
that other types of stored tissue may be used in place of fresh tissue. To test our hypothesis we compared FCM analysis of fresh tissue to samples stored in –20 °C, –80 °C, lyophilized fresh tissue, lyophilized frozen tissue stored at –20 °C and –80 °C, and air dried (herbarium specimens). We examined each treatment, in triplicate with tissue from (Penstemon eatonii, P. fruticosus, P. cyaneus, P. laevis, P. palmeri, P. venustus). We found that, compared to fresh tissue, all treatments showed degradation up to a 35% reduction in genome size. Contrary to our hypothesis, this reduction in genome size was not uniform across treatments for each species. It was concluded that with the current technology and procedures, there does not exist a good substitute for fresh tissue in the collection of FCM data of plant genomes.

**Organic Horticulture and Eorganic**

*Moderator:* Alexandra Stone  
Oregon State University, Corvallis, OR, USA  
2:15 PM – 2:30 PM

**Eorganic: Integrating Research-, Experience- and Regulation-based Information**

Alexandra Stone*  
Oregon State University, Corvallis, OR, USA

Alice Formiga  
Oregon State University and eOrganic, Corvallis, OR, USA

Since the establishment of the Organic Foods Production Act in 1990 there has been an urgent need for science-based information on organic agriculture. eOrganic is the Organic Agriculture Community of Practice at eXtension.org (eXtension.org/organic_production). Launched in 2009, eOrganic’s mission is to provide science-, experience- and regulation-based information on organic agriculture to farmers, agricultural professionals, researchers, students, and others. In addition to publishing general information about certified organic farming, eOrganic has partnered with 62 federally-funded organic farming research/outreach projects (NIFA OREI and ORG, Beginning Farmer and Rancher, Risk Management). SARE) in an effort to expand their national and global reach and impact. Over 300 contributors have delivered articles (http://articles.extension.org/pages/64401), videos (https://www.youtube.com/watch?v=uxHs2eM7YzY), webinars (http://articles.extension.org/pages/72567), and websites (http://eorganic.info/cornbreeding), and many more have presented at conferences/symposia (http://articles.extension.org/pages/33545) archived by eOrganic. eOrganic has published updates and findings from over 260 organic research projects on critical topics for organic farmers. All eOrganic articles undergo National Organic Program compliance review in addition to eOrganic’s peer-reviewed review process. eOrganic has hosted over 175 webinars which have been attended by over 20,000 people and the eOrganic newsletter reaches approximately 12,000. The eOrganic YouTube channel currently hosts 645 videos, archived webinars and conference recordings, and this content has attracted more than 7000 subscribers and 2.8 million views. eOrganic was initiated with a grant from NIFA OREI but is currently funded only by subawards and fees in research grants. To find out more or get involved, visit https://eorganic.info, where you can sign up for the eOrganic newsletter, find out how to include eOrganic in your next grant proposal, or learn what is required to publish an eOrganic article.

**Specified Source(s) of Funding:** NIFA OREI, ORG, Beginning Farmer and Rancher, Risk Management Agency, WSARE

2:30 PM – 2:45 PM

**Comparing Solarization and Tarping for Weed Management in the Northeast United States**

Sonja Birthsel*  
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Eric Gallandt  
University of Maine, Orono, USA

Mulching prepared beds with polyethylene sheets for several weeks before planting can create a ‘stale seedbed,’ reducing weed pressure in a subsequent crop. When clear plastic is used, this practice is called solarization; when black plastic is used, it is known as tarping. Though solarization and tarping have been studied and employed for pest control in warmer regions since the late 1970s, their application to weed management in the northeast United States is new. We conducted three site-years of field experiments near Orono, ME, comparing the efficacy of solarization and tarping for stale seedbed establishment. Solarization and tarping applied for 7 weeks in April-May of 2016 both created excellent stale seedbeds: two weeks after plastic removal, there was zero weed emergence in treatment plots, but significant weed emergence in check plots. Subsequent experimental site-years compared solarization and tarping applied for 2 weeks, 4 weeks, and 6 weeks during the summers of 2016 and 2017. Results were inconsistent between years: across treatment durations, 85% fewer weeds emerged following solarization as compared with tarping during the 2016 season, but in 2017, 94% more weeds emerged following solarization as compared with tarping. Factors that may have contributed to this discrepancy between years include soil moisture conditions and weed species. Notably, *Portulaca oleracea* (purslane) was abundant in the 2017 field site, comprising 45% of total weeds emergence in check plots, but a disproportionate 84% of weeds emerging in solarization treatments. This heat-tolerant species was not observed in our 2016 field site. In both years, solarization resulted in higher soil temperatures than did tarping. Solarization efficacy increased with treatment duration, but tarping efficacy was not consistently related to treatment duration. Soil biological activity was measured in 2016 only, and was not affected by treatment while mulch was in place. However, two weeks after plastic removal, soil biological activity was suppressed 18% following tarping and 43% following solarization in comparison with the check, suggesting that these practices can impact soil microbial communities. Overall, our results suggest that the relative efficacy of solarization and tarping for weed control in the northeast United States may be context dependent.
2:45 PM – 3:00 PM

**How to Use Paper Bags to Protect Organic Peaches from Insects and Diseases in the Southeastern United States**

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Within the organic fruit industry, peaches have experienced the largest increase in organic fruit acreage in the United States, but most of that acreage has increased in the west (Perez and Plattner, 2013). California, Washington, and Oregon currently supply the majority of domestic organic fresh market peaches (Hallberg, 2016). Peach producers in the southeast market fruit up to two months before west coast producers due to earlier warm temperatures and a later frost freeze damage potential. Producers select varieties that will set fruit when chill hour requirements are met (ranging from less to 100 to over 700), and can be harvested from late April through July to meet market demands. Organic peach production in the southeast has been difficult due to the prevalence of insect and disease pests, as well as the lack of effective organically-approved pesticides (Horton et al, 2005; Blaauw et al., 2017). In addition, many of the compliant, commercially-available pesticides contain copper and other ingredients that may negatively impact soil health with overuse (NOSB, 2017). Organic fruit producers in the US, Spain, Japan and China have been installing paper bags to provide a physical barrier from both pests and pathogens and have been able to increase fruit quality and increase yield (Sharma et al., 2014), but bagging peaches in the US is an emerging approach. In a pilot study funded by the Southern IPM Center, J. Melgar, and G. Schnabel from Clemson University demonstrated that bagging peach fruit can reduce fruit damage from pests and diseases, increase yield, and increase quality with an estimated net cost of ten to fifteen cents a pound (Hallberg, 2016). Pests and diseases can affect fruit quality throughout the entire growing season through postharvest. For example, the insect pests green stinkbug [Chinavia halaris (Say)] and plum curculio [Conotrachelus nenuphar (Herbst)] attack the fruit during initial development. Bacterial spot (Xanthomonas arboricola) is typically observed three weeks after petal fall, peach scab (Cladosporium carophilum) is spread early in the season when the humidity and temperature are optimum for growth, and the most prevalent end of season and postharvest fungal diseases include brown rot (Monilinia fructicola) and rhizopus (Rhizopus nigricans). To reduce pest-mediated damage, recyclable paper bags coated with a water resistant barrier are placed over fruitlets approximately ten days after full-bloom, when the when the fruitlet is approximately 1.5 cm × 3 cm, and removed approximately ten days before harvest to increase the blush color.

Specified Source(s) of Funding: NIFA OREI Project Number 2016-51300-25726

3:00 PM – 3:15 PM

**Food Hub Feasibility in Oregon’s Mid-Willamette Valley: Interviews with Conventional and Organic Small and Mid-sized Farmers**

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Javier Fernandez-Salvador
Oregon State University, Corvallis, OR, USA

Erica Chernoh
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A food hub is a centralized physical location or online resource that brings together farmers and food buyers. As such, food hubs can take many forms, including processing facilities, distribution centers, retail or wholesale markets, and educational platforms. They benefit small and mid-sized producers by providing infrastructure and resources that may be unavailable to farmers on their own. Food hubs are most commonly located in larger urban and metropolitan areas to maximize accessibility for growers, buyers, and consumers. A food hub feasibility survey was conducted by Oregon State University Extension Service Small Farms Program in partnership with the City of Salem in the mid-Willamette Valley. Salem is a city of 168,000 people and the second largest city in Oregon. The survey was conducted to determine small and mid-sized farmers’ interest in a potential food hub in a low income part of the city slated for urban renewal development. The first section of survey questions covered basic farm information and the second part focused on assessing farmer interest and determining specific requirements to participate in the project. Nineteen farmers were interviewed (7 certified organic, 12 nonorganic) and data were analyzed using one and two-way tables. Three quarters of the participants had heard the term food hub before the survey. Eighteen of the nineteen farmers interviewed were interested in participating in the food hub. All of the meat producers interviewed identified a USDA meat processing facility as the most helpful resource that a food hub could provide for them because of the lack of facilities in the region that will work with small producers. The top three concerns that both organic and nonorganic producers had about a food hub were: 1) prices would have to be set too low to justify participation, 2) possible lack of sufficient consumer demand for farm products, and 3) excessive competition from larger farms that would also participate in a food hub. Participants’ concern about a lack of consumer demand led them to request that the food hub provide community education about the value of buying local agricultural products. A higher percentage of organic (29%) than nonorganic (8%) farmers said the food hub was not necessary in the Salem area, citing their concern about...
a lack of demand for organic products. Establishing a food hub is a significant undertaking and assessing farmer, consumer and buyer interest through preliminary feasibility surveys is essential.

3:15 PM – 3:30 PM

Reusable Black Tarps Suppress Weeds and Make Organic Reduced Tillage More Viable

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Organic vegetable farmers rely on intensive tillage to control weeds, incorporate amendments and residues, and prepare seedbeds. Intensive tillage, however, can lead to a decrease in long-term soil health. The use of black, impermeable, polyethylene tarps on the soil surface prior to planting reduces weed pressure, increases crop yield, and preserves prepared soil for several weeks. Cultivar ‘Boro’ beets were planted on two dates: 16 May 2017 and 15 June 2017. Tarps were applied and left in place for three time periods prior to projected planting dates: 1) either overwinter (early planting) or 10 weeks (late planting), 2) six weeks, and 3) three weeks. After tarp removal, plots were roto-tilled (4 in.), shallow-tilled (1 in.), or left as is (no-till), then direct-seeded with beets. No-till plots received no weed control, tilled plots were cultivated at 10 and 20 days post-planting. Weed pressure, crop yield, and soil conditions were measured at tarp removal, midseason, and at harvest. Use of tarps for any length created a seedbed free of weeds prior to planting and kept weed biomass lower than the control the first three weeks after planting. Total soil nitrogen increased linearly ($R^2 = 0.7$) with increased tarp duration. While there was often a significant difference in weed biomass and crop yield between shallow- and roto-tilt treatments without tarps, there was never a significant difference between shallow- and roto-tilt treatments when tarps were used. A tarp duration of three weeks was sufficient to achieve reduced weeds and increased yield.

Specified Source(s) of Funding: NIFA OREI and Toward Sustainability Foundation

3:30 PM – 3:45 PM

Options for Including Cover Crops in High Tunnel Crop Rotations

Anne Pfeiffer
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High tunnels are a popular season extension tool used by growers to increase yield and produce quality of vegetables, fruits, and flowers. Intensive cropping in these spaces can lead to soil health problems, such as reduced organic matter and increased soil salinity, that may impact yield. Cover crops are a potential management tool to increase soil organic matter and, in the case of legumes, add nitrogen without importing excess salts. Cover crops can also help with weed control and can disrupt certain pest and disease cycles. While cover crops have many benefits, they can be challenging to include in high tunnel crop rotations because there is little time between cash crops and some aspects of management are more complicated than in the open field. This paper discusses management strategies, benefits, and challenges of cover crops in high tunnels and different rotational windows including fall-planted winter-killed, fall-planted overwintered, spring planted, summer planted, and inter-planted cover crops.

Genetics and Germplasm 3

Moderator: Theodore Kisha
USDA-ARS, Pullman, WA, USA

2:30 PM – 2:45 PM

Phylogenetic Analyses Confirm the Unique Status of the Wild New World Melon, Cucumis melo ssp. agrestis var. texanus, and Suggest It be Tentatively Designated Group Texanus in the Recent Revision of Melon Nomenclature

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Cucumis melo ssp. agrestis var. texanus Naudin is a wild melon found from the southeastern Unnited States to eastern and western Mexico. It is weedy, prolific, and bears many small non-sweet fruit with small seeds, and is a potential source of powdery mildew and nematode resistances. Var. texanus was, until classified as a separate varietas, considered a member of C. melo ssp. melo var. chito, a small melon from Central America and the Caribbean Islands, or var. dudaim, a small fragrant melon from the Middle East and Central Asia. The U.S. National Plant Genetic Resources System (NPGS) maintains 2000+ C. melo Plant Introductions (PI). Forty-four of them are var. texanus,
Characterization of the USDA Germplasm Collections for Watermelon, Melon, Cucumber and Squash Using Genotyping-by-sequencing

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Germplasm collections are a critically valuable source of genetic diversity for plant breeding efforts. Our ability to make optimal use of such resources for crop improvement is facilitated by genetic characterization. Therefore, one of the objectives of the CucCAP project, “CucCAP: Leveraging applied genomics to improve disease resistance in cucurbit crops”, is to characterize genetic diversity within the U.S. cucurbit plant introduction (PI) collections and develop sequence-informed functional panels for genetic and phenotypic analyses. To this end, we have performed genotyping-by-sequencing (GBS) analysis of the USDA PI collections of the four major cucurbit crops: watermelon (Citrullus lanatus), melon (Cucumis melo), cucumber (Cucumis sativus), and squash (Cucurbita pepo and C. moschata). A total of 1,234 cucumber, 2,077 melon, 1,365 watermelon, 850 C. pepo, and 314 C. moschata accessions were genotyped. A total of 1.57, 1.71 and 0.88 billion GBS reads were obtained for cucumber, melon and watermelon, respectively. From these reads, 76.9, 54.2, and 34.6 million unique tags were obtained, of which 593,678, 743,545, and 388,298 tags with at least 10 reads were used for SNP calling for cucumber, melon and watermelon, respectively. A total of 114,338, 89,377 and 62,258 SNPs were called in cucumber, melon and watermelon, respectively, and 23,828, 27,846, and 25,930 SNPs were obtained by applying criteria of missing data rate < 0.5 and minor allele frequency (MAF) > 0.01. The SNPs were well distributed across the genomes with average density of one SNP per 10.6, 14.6, and 15.7 kb for cucumber, melon and watermelon, respectively. Using these SNP data, we have performed population structure and principal component analysis (PCA), and constructed a neighbor-joining trees to infer phylogenetic relationships among the accessions. These analyses are being used to establish functional panels of ~300-400 accessions per crop representing ~99% of the genetic diversity along with key disease resistance, fruit quality, horticultural and agronomic traits.

Specified Source(s) of Funding: USDA-SCRI 2015-51181-24285
Examination of Extractable Phenolics and Non-extractable Proanthocyanidins from a Selection of “Red” and “Black” Market Class Accessions of Beans from the National Plant Germplasm System

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Girish Ganjyal
Washington State University, Pullman, WA, USA

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Beans (Phaseolus vulgaris L.) are one of the most economically and nutritionally important crops world-wide. They are the most important legume for direct human consumption with a value of over $20 billion harvested (FAO statistics, 2014); more than twice that of the next most important legume, chickpea (Cicer arietinum L.). Beans have numerous nutritional qualities, such as high protein, high amounts of starch, dietary fiber, minerals, and an array of healthy phytochemicals associated with health benefits such as reduced cardiovascular disease, the prevention of diabetes, and even the prevention of cancer. One important class of phytochemicals includes polyphenolic compounds which impart color, flavor, and anti-oxidant activity. Growing consumer awareness regarding the health benefit of beans in general will likely increase demand, perhaps especially among those who frequent farmers markets and health food stores. Market classes of “Red” and “Black” beans are thought to be among the highest in phenolic content and antioxidant activity. Preliminary analysis however, showed 2- to 3-fold differences within each market class. We analyzed extractable phenolics and nonextractable proanthocyanidins from a large selection of red and black beans to provide information to breeders to enhance these nutritional components within each market class.

Specified Source(s) of Funding: Project Number: 2090-21000-032-00-D

Improving Transfer of Traits from Solanum Pennellii to Cultivated Tomato by Understanding Segregation Distortion and Reproductive Barriers

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The germplasm of many crops including tomato is narrow due to constraints imposed during domestication, thus increasing the importance of wild relatives as a source of genetic variation. However, segregation distortion, linkage drag and reproductive barriers impede the transfer of desirable traits from the wild to cultivated species. This project was undertaken to understand segregation distortion and reproductive barriers in the $F_1$ and backcross (BC) populations from the interspecific cross between tomato, S. lycopersicum, and the wild species, S. pennellii. The three populations derived from crosses between S. lycopersicum M82 and S. pennellii LA716 and their interspecific F$_1$ were evaluated for % pollen stainability and % seed germination as well as if plants produced flower, fruit or seed. Percent stainable pollen varied greatly for the parents: 99.22% M82, 16.31% LA716 and 85.7% of the interspecific hybrid, F$_1$. Both backcross populations had similar means, 57.9% BCLyc and 48.9% for BCPen, while the $F_2$ mean was 31.7% but varied from zero to 99.2%. The $F_2$, as expected from previous research had only 27.75% of the population producing fruit, of which, only 9.43% produced seed. As expected, all of the BCLyc flowered and 98% produced fruit with germinable seed. Conversely, the majority of the BCPen produced flowers, but only 8.7% of the plants produced self-fruit and only 3.26% produced seed. Only two populations, $F_2$ and BCLyc exhibited any abnormal seed germination (18.8% and 1.1% respectively), with all of the germinated seed from the $F_2$ being abnormal. Of the 1000 SNP markers, 181 had no data and an additional 184 had no variation or were incorrect, leaving 635 markers used for analysis. The $F_2$ population had 43% of the markers deviate from the expected 1:2:1 ratio. The BCLyc population had over 63% of their markers deviating from the 1:1 ratio with excess tomato alleles and all of the markers on two chromosomes skewed. The BCPen population, only 21.9% displayed distorted segregation and one chromosome did not skew from the expected ratio. In addition, most of the skewing BCPen markers favored homozygous LA716 combination, but a few skewed toward the heterozygous combination on chromosomes 5 and 9. Each population was examined for the percent of S. pennellii genome present with 50% expected for the $F_1$ and 54.4% observed. The two backcross populations were projected to have 25% (BCLyc) and 75% (BCPen), our analysis found an average of 17.8% for BCLyc and 77.6% for BCPen respectively.

Specified Source(s) of Funding: This project was supported by Agriculture and Food Research Initiative Competitive Grant no. 2012-38821-20049 from the USDA National Institute of Food and Agriculture

Identification of Phosphorus-efficient Genotypes from Tomato Germplasm

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Phosphorus is the second most essential nutrient element for plants, following nitrogen. Phosphorus fertilizer is made from mining phosphate rock, however, these reserves are finite and depleting. With increasing global demand for fertilizer and a shrinking supply, it is imperative to find efficient means to utilize phosphorus. Phosphorus occurs in soils as organic (Po) and inorganic (Pi) forms, all mainly insoluble and unavailable. Growers commonly use fertilizer as an insurance for
crop production, but over-fertilization commonly occurs as a result which causes eutrophication. Some cultivars are able to mobilize insoluble phosphates due to mechanisms such as changing root architecture, microbial associations, or exuding organic acids. The objective of this experiment is to examine seven tomato (*Solanum lycopersicum*) genotypes collected from a pre-identification trial—Great White Og, Japanese Black Trifele, Mariana F1, Juliet F1, Cherokee Green, Chef’s Choice Orange, and Pink Bumble Bee—under conditions of insoluble phosphate, tri-calcium phosphate, to identify elite genotypes. This trial will be carried out by growing tomato seedlings in a 10% Hoagland solution-based hydroponics system until two sets of leaves fully expand. Chlorophyll content, pH, height, biomass, and concentration of N, P, and Ca will be determined. Based on the pre-identification data, we hypothesize that ‘Great White Og’, ‘Japanese Black Trifele’, and ‘Mariana F1’ will have the lowest P content, highest P content, and highest Ca content respectively. We also hypothesize that the P-efficient tomato (Japanese Black Trifele) will have greater height, greater biomass, greater root to shoot ratio, greater chlorophyll content, and lower pH. These results will help to aid breeders in selecting for traits that are associated with phosphorus use efficiency. Growing phosphorus efficient crops can minimize environmental damage from over-fertilization and can slow depletion of the finite phosphorus reserves.

**Plant Growth Regulation 1**

*Moderator: Janet Slovin*

USDA/ARS, Beltsville, MD, USA

2:30 PM – 2:45 PM

**The Morphological and Genetic Effects of Exogenous Auxin and Gibberellin Application on Apple Fruit Development**

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Fruit set and development are dependent on the plant hormones auxin and gibberellin, which can create parthenocarpic, seedless fruit in many species when applied ectopically. In the apple fruit, a pome, these hormones trigger the enlargement of the hypanthium, a cup-like structure which surrounds the ovary and forms the majority of the fruit flesh. Sprays containing these hormones are available commercially with the purpose of improving apple fruit set, size and shape, but results may vary. This variability, in combination with reports that hormone sprays may cause lower fruit quality at maturity, highlight the need for research in this area. We applied gibberellic acid (GA$_3$), synthetic auxin (NAA) and both, in addition to the auxin-transport inhibitor NPA to ‘Honeycrisp’ apple flowers. Our results showed that GA$_3$ applications alone caused the development of parthenocarpic apples. At maturity, GA$_3$-treated apples had a slightly different shape but were similar in quality to hand-pollinated controls, though they were less acidic. This contradicts previous reports of accelerated ripening leading to quality issues at harvest. We performed RNA-sequencing analysis on hypanthium, ovary and ovule/seed tissues from GA$_3$-treated, NAA-treated and control fruits, and found that while GA$_3$-treated parthenocarpic and hand-pollinated fruit were the most similar in RNA expression profiles, interesting differences do occur. We focused on the apple GA20ox, GA3ox and GA2ox orthologs, which have been shown in other species to synthesize or degrade bioactive GA. We found that many members of these families exhibit unique responses to pollination, GA$_3$, and/or NAA treatment, which may play a role in the morphological differences we observed. Taken together, our data have led to a preliminary characterization of the roles of these genes and expands upon the function of GA in apple fruit development.

*Specified Source(s) of Funding: NSF-IOS 1444987, Agricultural Research Services*

2:45 PM – 3:00 PM

**Auxin Metabolic Relationships in the Diploid Strawberry**

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Janet Slovin*

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Strawberry fruit growth is a classic system for studying auxin signaling between tissues during fruit development. The juicy flesh of the strawberry results from enlargement of the stem tip (the receptacle) underlying the carpels in response to auxin and gibberellin produced by the developing achenes, the botanical true fruit. The auxin originates in the achenes, which spiral up the outside of the receptacle. In later stages of berry development, auxin slows the ripening process. The literature describes a pattern of free auxin (IAA) accumulation in the developing berry suggestive of active metabolic and/or transport activity that sustains the enlargement of the receptacle after embryo development is complete. In diploid strawberry, *Fragaria*...
Transcriptomic Study of the Early Responses to Bud-break Agent Hydrogen Cyanamide in ‘Tropicbeauty’ Peach

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Hydrogen cyanamide (HC) is used in deciduous fruit trees to induce bud endo-dormancy release and to offset insufficient chilling hours for bud break. The objective of this study was to gain insight into the mechanism of bud break response to HC in ‘Tropicbeauty’ peach trees (Prunus persica L.) by comparing buds from HC-treated and non-HC-treated control trees, respectively, at the global transcriptomic level using RNA sequencing. For HC-treated trees, the peak of bud burst (7 flower buds and 10 vegetative buds/branch) occurred at 32 days after treatment (DAT). In contrast, control trees had maximum release of bud dormancy (10 flower and 14 vegetative buds/branch) at 74 DAT, six weeks later than treated with HC, suggesting HC accelerated bud break in peach. Between HC-treated and control trees, there were 1312 and 1095 differentially expressed genes (DEGs) at 3 and 7 DAT, respectively. The results of gene ontology (GO) enrichment analysis demonstrated that at 3 DAT, significant GO terms with top enrichment values (EV) included cell proliferation (EV = 8.0), regulation of multicellular organismal process (EV = 7.1), chromosome organization (EV = 6.7), and anatomical structure development (EV = 6.1). Interestingly, at 7 DAT, top GO terms for up-regulated DEGs shifted to cell cycle (EV = 9.7), chromosome organization (EV = 9.5), chromatin organization (EV = 8.7), and cell cycle process (EV = 8.7), indicating resumption and increase in cell division and growth following the initial suppression by HC treatment. For down-regulated DEGs at 7 DAT, top GO terms included response to stimulus (EV = 6.9), response to chemical stimulus (EV = 6.2), and response to stress (EV = 3.6). The results suggest HC induces oxidative stress in buds shortly after application leading to the release of bud dormancy and subsequently causes increased cell activity, resulting in floral and vegetative bud break.

Oral Presentations

Interaction between ABA Metabolism and Light Quality on Anthocyanin and Sugar Syntheses in Grapes

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The interaction between abscisic acid (ABA) and blue or red light irradiation on anthocyanin and sugar syntheses in ‘Kyoho’ (Vitis labrusca × V. vinifera) grape berries was examined. The following two experiment groups were created. In the first group, ABA antagonist of PYL-PP2C receptor (AS-6) was treated to the cluster at 38 days after full bloom (DAFB) (one week before veraison) and 48 DAFB (veraison). The second group was the untreated control group. The anthocyanin and sugar concentrations, ABA metabolism, and their related gene expressions were analyzed at 38, 48, 58, and 68 DAFB. The anthocyanin, glucose, fructose, sucrose concentrations, and the VlMybA2 and VvUFGT expression levels were inhibited in AS-6 treated berries. In contrast, the expression levels of VvPC2C9 in AS-6 treated berries were increased at 48 DAFB. These results suggest that endogenous ABA is associated with anthocyanin and sugar syntheses in grape skin. To consider the effects of light on ABA metabolism and anthocyanin formation, three experiment groups were created. In the first group, blue (clusters)/blue (leaves) LED was similarly irradiated for six hours at night from full bloom to harvest. In the second group, blue (clusters)/red (leaves) LED was similarly irradiated. The third group was the untreated control. The VvNCED1 expression levels were increased in the first and second groups compared to the untreated control. The CYP707A1 expression levels in the second group was decreased at 62 DAFB. The VvPP2C9 expression levels in the first and second groups were inhibited. These expression levels influenced ABA concentrations in the skin. The anthocyanin concentrations were increased in the first and second groups. These results suggest that light quality influences ABA metabolism, resulting in anthocyanin formation in the grape skin.

An asterisk (*) following a name indicates the presenting author.

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3:00 PM – 3:15 PM

Abscisic Acid Is Involved in Aromatic Ester Biosynthesis Related with Ethylene in Green Apple ‘Orin’

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The production of aromatic volatiles such as esters during the ripening process in climacteric fruits is known to be controlled by ethylene. However, we here show that abscisic acid (ABA) application accelerated the onset of short-chain ester production (hexyl propionate, ethyl-2-methyl butyrate) and the expression of biosynthesis genes (MdACS1/3 and MdBCAT1) during ripening of ‘Orin’ apple. ABA application also promoted the production of ethylene, and caused ethylene peak shifts correlated with the expression of ethylene synthesis genes (MdACS1/3 and MdACO1), suggesting that ABA may act jointly with ethylene as a positive regulator at the ripening stage of ‘Orin’ apple. Additionally, endogenous levels and expression of biosynthesis (MdNCED1) and signal transduction genes (MdABF2-like) of ABA increased toward ripening. Finally, the localization of the putative MdABF2-like protein binding element, AREB/ABF, was observed in the 5’-upstream region of MdACS1/3 and MdACO1.

Growth Chambers and Controlled Environments 3

Moderator: Brandon M. Huber
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2:30 PM – 2:45 PM

Hydroponic Systems for Small-scale Indoor Food Production

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Technology can help overcome some of the issues associated with urban farming, such as the lack of knowledge for indoor-plant production in a non-controlled home environment. Because indoor-home growers are producing plants on a much smaller scale compared to commercial growers, research in this area has been largely neglected over the years. However, indoor-home growers face significant production challenges that cannot be addressed with research focused on large-scale commercial production. The lack of information available regarding the production capabilities of ‘indoor hydroponic gardens’, especially with regard to the minimum inputs required to effectively operate a productive system that can provide a continuous supply of high-quality fresh produce, is affecting our ability to provide consumer-oriented guidance regarding techniques and requirements to produce edibles (e.g., herbs, vegetables) indoors. A 12-week experiment (6 Feb. through 30 Apr. 2018) is being conducted inside a poly-carbonate greenhouse located in Gainesville, FL. The objective of the study is to determine the minimum number of intervals required to change a nutrient solution without sacrificing harvestable yield for tomato (Solanum lycopersicum) and basil (Ocimum basilicum). Eight treatments are being evaluated using either a water-soluble or a pre-mixed liquid nutrient solution were nutrients are being added every 2 weeks to all treatments to a pre-set volume of water. Regardless of nutrient formula, water and nutrients are completely replaced every two, four, or eight weeks; a control treatment is also included were no water is replaced. Results from this experiment will be presented.

2:45 PM – 3:00 PM

Recycled Nutrient Solution Effects on Hydroponic Lettuce Growth in Deep Water Culture and Nutrient Film Technique

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Nutrient solution is constantly recycled by maintaining electrical conductivity (EC) in commercial hydroponic production. In recycled solutions, nutrients taken slowly by plants (ex Ca, Mg, and S) tend to accumulate and affect EC. Thus, for a given EC measured in the solution, recycled solution is relatively low in quality compared to fresh solution. Our hypothesis was that recycled nutrient solution can reduce nutrient availability to roots in Nutrient Film Technique (NFT, a thin film of solution) compared to Deep Water Culture (DWC, roots submerged in nutrient solution), due to higher volume of nutrient solution available to roots for nutrient uptake in DWC than NFT. A second hypothesis was that the portion of root system not exposed to nutrient solution under NFT may experience mild to moderate drought stress and affect crop growth. Lettuce (Lactuca sativa L.) was grown under hydroponic conditions in a greenhouse maintained at 22/20 °C (day/night) temperature and daily light integral of 15 mol·m⁻²·d⁻¹ in three separate experiments. In experiment I, three varieties of lettuce (Black Seeded Simpson, Rex, and Redina) were grown under NFT and DWC using recycled nutrient solution. When data from three varieties were pooled, a significant decrease in shoot dry weight and increase in root
dry weight were observed under NFT compared to DWC. These results could be due to nutrient or drought stress or combined effect of both stresses under NFT than DWC. Experiment II grew lettuce (var. Rex) in fresh and recycled solutions, each with NFT and DWC systems. No differences in crop growth between DWC and NFT were observed when fresh solution was used but a lower growth in NFT than DWC was observed when recycled solution was used. This data suggests the decreased plant growth in NFT with recycled solution was likely due to lower nutrient availability. However, plants in NFT compared to DWC did not experience drought stress, as there were no differences between NFT and DWC when fresh solution was used. A third experiment using leaf lettuce (var. Black Seeded Simpson) tested fresh and recycled solution in an NFT system. There was a significant increase in shoot dry weight of plants under fresh than recycled conditions. Tissue nutrient analysis indicated suboptimal concentration of N, P, and K in the recycled compared to the fresh solution treatment. These results confirm that reduced growth in NFT system under recycling conditions is due to low nutrient availability to plants.

Specified Source(s) of Funding: Purdue University

3:00 PM – 3:15 PM

Optimizing Production of Tomato Transplants for Grafting Using Lower DLI and Supplemental CO₂

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Grafted plants offer several advantages for tomato growers including resistance/tolerance to soil borne pathogens and increase in yields. In the United States, the demand for grafted vegetable seedlings has increased in the last few years. Precision Indoor Productions (PIP) systems offer advantages for the propagation of grafted seedlings such as control of the environment and increase in spatial and temporal plant uniformity. However, these systems are energy intensive due to the use of electrical lighting as the energy source for plants. CO₂ supplementation is inexpensive for closed systems and has shown to improve yield for many crops. The objective of this experiment is to decrease the light requirements and increase CO₂ levels to produce a high-quality tomato seedling while reducing energy consumption. Two tomato cultivars were grown scion ‘Rebelski’, and rootstock ‘Maxifort’. Plants were subject to three different light treatments 100PPF (103 ± 7.4), 150PPF (152 ± 5.8), and 200PPF (200 ± 11) photosynthetic photon flux (mmol·m⁻²·s⁻¹) (18 h) with a percent photon flux ratio of 60 Red:40 Blue. Furthermore, plants were also exposed to end-of-day far-red light at 5 mmol·m⁻²·d⁻¹. Plants were also subjected to three different CO₂ treatments of 400 CO₂ (439 ± 23) (ambient), 1000 CO₂ (1018 ± 42), and 1600 CO₂ (1589 ± 10) μmol·mol⁻¹. The room air temperature was 24.3 °C ± 0.5/16.7 °C ± 1.1 (day/dark) (22.4 °C average), and 51.9 ± 8.2% relative humidity. Tomato seedlings were grown until the grafting stage (1.8–2.0 mm stem diameter). Daily morphological measurements were taken to observe the growth response over time. In addition, dry mass and other morphological and physiological data was collected to quantify the effects of each treatment. Preliminary results show that under 200PPF–1600 CO₂, ‘Rebelski’ reached grafting stage at day 14, 12% earlier than the control (200 PP–400 CO₂). ‘Maxifort’ grown at 200 PP–1600 CO₂ reached grafting stage at day 17, 6% earlier than the control (200 PP–400 CO₂). In addition, the same plant growth was obtained under 25% less PPF and elevated CO₂ (1000–1600 μmol·mol⁻¹) as with standard growing conditions (ambient CO₂ at 200 mmol·m⁻²·s⁻¹).

Specified Source(s) of Funding: Award number 2016-51181-25404

3:15 PM – 3:30 PM

Gas Exchange and Leaf Anatomy of Lettuce in Response to Red and Blue Sole-source Lighting from LEDs

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The sustainability of long-duration manned missions in space relies on plant-based Bioregenerative Life Support Systems (BLSSs). Providing optimal light conditions in closed environments is crucial for proper design and optimization of space-based plant growth chambers. Light-emitting diodes (LEDs) are a promising electric light source for BLSSs research because of their inherent capability to provide accurate spectral control as a function of specific crop requirements. In addition, the capability they offer to modulate light quality allows for plant photoreceptors to perceive light cues that can improve yield and nutritional attributes of food crops. The objective of this study was to quantify the effects of blue light on growth and morphology, photosynthesis (A), stomatal conductance (gs), transpiration (E), chlorophyll estimation (SPAD index), and anatomical features of ‘Waldmann’s Green’ and ‘Outredgeous’ lettuce (Lactuca sativa) grown under different red-to-blue-light ratios. Five treatments were evaluated in the study: 100% red; 7% blue + 93% red; 26% blue + 74% red; 66% blue + 34% red; 100% blue. All treatments provided an average daily light integral (DLI) of 11.5 μmol·m⁻²·d⁻¹ (200 ± 2 μmol·m⁻²·s⁻¹ over a 16-h photoperiod). The effect of light treatments on leaf structure was measured comparing anatomical traits by using light and fluorescence microscopes equipped with camera and software for digital image analysis. The experiment was replicated four times; each experimental replication was terminated 22 d after treatment initiation. Preliminary findings suggest that regardless of treatment, A, gs, E, SPAD index, and biomass production

An asterisk (*) following a name indicates the presenting author.
are higher for ‘Waldmann’s Green’ compared to ‘Outredugeous’ plants. Treatment comparisons indicate that except for 100% blue, the increasing percentages of blue light increased A, gs, E, and SPAD index, but decreased leaf area and edible biomass production. Final results from this experiment, including a discussion on the function of leaf anatomy in response to light-quality, will be presented.

Specified Source(s) of Funding: University of Naples Federico II

3:30 PM – 3:45 PM

**Optimum Light Intensity for the Production of ‘Albion’ Strawberry Tips in Precision Indoor Propagation Systems**

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The current open field strawberry propagation method in the US has intrinsic problems such as seasonal scarcity, low productivity, and plants have a high risk for contamination with soil borne pathogens. A potential alternative is precision indoor propagation (PIP). The overall objective of this project is to maximize strawberry tip production (reduce flower initiation) by precisely controlling all the environmental factors to provide affordable and clean propagation material. The objective of the present experiment is to find the optimal light intensity to maximize strawberry propagation efficiency (tips per mother plant). ‘Albion’ (day-neutral) strawberry plugs (27) with two expanded leaves and crown diameter of 7.3 ± 0.8 mm were transplanted in one-gallon pots filled with a substrate mixed of 50% perlite, 25% peat moss and 25% coconut coir. Potted plants were placed in a custom designed indoor strawberry propagation system. Plants were subject to three different light intensity treatments: 250PPF (251 ± 11), 350PPF (345 ± 13), and 450PPF (446 ± 14) photosynthetic photon flux (mmol·m⁻²·s⁻¹) at 12 h photoperiod provided by cool white fluorescent lamps. The canopy air temperature was maintained at 27.6 ± 0.3°C / 23.9 ± 0.2 °C during the day/dark period, relative humidity of 63.1 ± 4.4 % and ambient CO₂. The plants were watered through electronic irrigation system with modified Yamazaki recipe. Preliminary data shows that after three weeks of growth, there is no significant difference between the three treatments in leaf count and flower development, treatments have produced 5.7 ± 1.6 flowers and the canopy has 5.4 ± 0.6 leaves. Plants under 450PPF have 16% and 12% greater crown diameter (14.3 ± 1.2 mm) than plants under 250PPF and 350PPF treatments, respectively. Runners will be harvested when the first tip has two expanded leaves, and the third tip starts developing. Number of tips per mother plant and tip growth rate and morphology will be recorded. In addition, mother plant growth rate and morphology will also be recorded.

3:45 PM – 4:00 PM

**Performance and Yield of Vegetable Crops Are Affected by Water Flow-rate in Aquaponics Systems**

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Aquaponics is a rapidly emerging agricultural production system, which recycles effluent from aquaculture to feed crops with nutrients, creating a symbiotic ecosystem for fish, microbes, and plants production in a closed system. Water and nutrients added into aquaponics system are recycled for fish and crop production, and therefore, water flow rate in an aquaponics system may be associated with water environment such as water quality and nutrient availability, consequently affecting the performance and growth of crops grown in the system. In addition, since different crop species have different production periods and nutrient requirement, their performance and yield may be also varied by water environment in an aquaponics system. This study was conducted to investigate the performance and growth of crop species in an aquaponics system with different water flow rates. Six vegetable crops varying in their production period were cultured in tilapia-based aquaponics systems, which include basil (Ocimum basilicum), chia (Salvia hispanica), Tokyo Bekana (Brassica rapa), lettuce (Lactuca sativa), mustard (Brassica juncea), and Swiss chard (Beta vulgaris). Water flow rates were set at low (1000 L/day, LFR), medium (2000 L/day, MFR), and high (3000 L/day, HFR). Fish were fed once a day with fish feed by 1% fish fresh weight. Water quality parameters (dissolved oxygen (DO), mg·L⁻¹; temperature, °C; pH; electrical conductivity (EC), μS·cm⁻¹) were measured daily. The pH was adjusted by using a mixture of potassium hydroxide and calcium hydroxide (v:v = 1:1) at around 7.0. Water was sampled for total ammonium nitrogen (TAN), nitrite, nitrate, and phosphate measurements every three days. Photosynthetic rate (Pn) and leaf temperature were measured at the third week when crops showed highest growth rate. At harvest, crop growth parameters were measured, including plant height, leaf length, leaf number, chlorophyll content (SPAD value), and leaf area. Initial and final fresh and dry weights of fish and vegetable crops were measured. Data showed that HFR significantly lowered the pH, EC, water temperature, TAN, nitrate and phosphorus. During the second and third week, the pH in HFR was significantly lower than LFR. EC in HFR was significantly lower than that of LFR from the second week. Particularly, TAN and nitrate concentration was significantly lower in HFR in the first week compared to LFR. Such water environment in HFR improved crop growth in aquaponics. The SPAD and Pn values of crops in HFR/MFR were significantly higher than LFR. Crops in HFR showed significantly higher total dry weight from increased shoot and root dry weights. HFR improved crop performance and yield in aquaponics possibly through enhancing environ-
ment for microbial nitrification activities, which might have led to better environment for crops to uptake nitrate and phosphate demonstrated by lower EC and nitrate and phosphate in the effluent. Interestingly, crops in different production periods also showed different growth performance during the study. Fast-growing crops showed significant higher total fresh weight, shoot fresh weight, leaf area, Pn than slow-growing crops. In summary, we concluded that high water flow rate at 3000 L/day improved performance and yield of fast-growing crops in an aquaponics system.

Specified Source(s) of Funding: USDA-AFRI

4:00 PM – 4:15 PM

Effect of Substrate Volumetric Water Contents on Growth and Secondary Metabolite Contents of Lysimachia Mauritiana Lam.

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Plants of genus Lysimachia including L. mauritiana L. inhabit in the relatively desiccate environment such as crevice of coast rock, and they are known to have antioxidant, anti-inflammatory, anticancer, and antimicrobial activities due to their flavonol glucosides. This study was conducted to investigate the effect of substrate volumetric water contents on growth and secondary metabolites of L. mauritiana which are one of the native plants in Korea. The seeds of L. mauritiana provided by Korean National Institute of Biological Resources (NIBRGR0000175023) were sown on 128 plug tray in a greenhouse in May 2017, and the germination rate and days to germinate were 74.2% and 14.8 days. The seedlings were transplanted into 4-inch pots with a soilless substrate (Sunshine Mix4, Sun Gro Horticulture, Agawam, MA, USA) mixed with a controlled released fertilizer (Multicote 6, Haifa Chemicals, Israel) at a ratio of 4 g·L⁻¹ at 45 days after sowing. After a month of the acclimation period, soil moisture sensor-based automated irrigation system maintained the substrate volumetric water contents at four different levels (0.3, 0.4, 0.5, or 0.6 m³·m⁻³) using capacitance sensors and a datalogger. Plant height, number of leaves, leaf area, leaf water potential, chlorophyll content, fresh weight, dry weight, and photosynthetic rate were measured at 0, 5, 11, and 18 days after treatment. At 5 days after treatment, there were no significant differences in vegetative growth among all the treatments, but leaf water potential, photosynthetic rate, transpiration rate and stomatal conductance were the lowest in 0.3 m³·m⁻³ treatment, indicating physiological drought stress. On the contrary, at 11 days after treatment, there were no significant differences in leaf water potential and photosynthetic rate, but all vegetative growth parameters except root dry weight were lower in 0.3 m³·m⁻³ treatment than those in other treatments. As substrate volumetric water content decreases, root fresh weight decreases, indicating root water content was affected by substrate volumetric water content. The results at 18 days after treatment was similar to those at 11 days after treatment, which showed significant differences in physiological responses but no significant differences in vegetative growth in most parameters. However, photosynthetic rate was lower in 0.3 m³·m⁻³ treatment than other treatments, although there were no differences in stomatal conductance and transpiration rate. It was likely due to severe and continuous drought stress, possibly imposing disorders of certain enzymes related to photosynthesis such as Rubisco. Although there was a slightly increasing tendency in antioxidant capacity under drought at 5 days after treatment, there were no significant differences in total phenolic content and antioxidant capacity among the treatments. When cultivating L. mauritiana, the growth and secondary metabolites would be affected by the substrate volumetric water contents, and they could be changed by the duration of drought. To optimize the growth and secondary metabolite contents in plants, further experiments with controlled drought at various levels, imposing times, and the duration of drought may be required.

Specified Source(s) of Funding: This work was supported by grants from Korea University and the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR201820101).

Water Utilization and Management 1

Moderator: Damon Abdi
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2:30 PM – 2:45 PM

The Change in Photosynthetic Activity and Leaf Water Content of Squash Plants Treated with Bacteria and Methylamine under Drought Conditions

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Oral Presentations

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In some parts of the world droughts are threatening the supply of fresh vegetable production and currently a major limiting factor in agricultural productivity especially in developing regions. Some prospective strategies for improving drought tolerance may become increasingly more effective if the complex mechanism in the plant could be understood. For this reason, we investigated the change of photosynthetic activity, leaf water content and electrolyte leakage of squash (Cucurbita pepo L. cv. Sakız) under different irrigation levels with three different bacteria strains (Bacillus megaterium TV-91C, Bacillus megaterium TV-6D, Bacillus subtilis RK-1900) and product of methylamine (MA). Four irrigation levels [Full-irrigation; 100%, irrigation with 85% of the full-irrigation (mild); irrigation with 70% of the full-irrigation; and irrigation with 55% of the full-irrigation (severe)] were followed in field. The effects of the applications on photosynthesis (Pn), stomatal conductance (gs), transpiration rate (Tr), concentration of intercellular CO2 (Ci), electrolyte leakage (EL) and leaf relative water content (LRWC) of squash under water stress were observed. In full irrigation, the highest gs and Tr were obtained at RK1900+MA application, while the highest Pn and LRWC were recorded at of TV91C+MA application. We found that TV91C was the most effective bacteria on photosynthesis activity that caused 20% increase under full irrigation and 28% increase under severe drought conditions.

Specified Source(s) of Funding: TUBITAK

2:45 PM – 3:00 PM

Overcoming Barriers to Use of Nursery Run-off Water: Understanding Plant Sensitivity to Residual Pesticides

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Nursery uses a significant amount of water, fertilizers, and pesticides. In the year 2013, nurseries in the United States (U.S.) used around 775 million cubic meters of water. The number of the nurseries in the U.S. is increasing which has led to the production of the significant amount of runoff water. Ioxaben, chlorpyrifos, and oxyfluorfen are common pesticides found on nursery run-off water, which if present at a higher level may have adverse effects on nursery plants. Nursery growers are often hesitant to use of runoff water due to concerns about adverse impacts of residual pesticides. Hence our research focused on determining the damage threshold of those pesticides to common container-grown nursery plants. Hydrangea, Cornus, and Hosta are common nursery plants and vary in the degree of sensitivity to common pesticides. Hence Hydrangea paniculata ‘Limelight’, Cornus obliqua ‘Powell Gardens’, and Hosta ‘Gold Standard’ were used for the study. Levels of pesticide were chosen based on their reported level in runoff water. Application rates for each pesticide were 0, 0.15, 0.35, 0.7, and 1.4 mg L−1 of isoxaben, 0, 0.05, 0.1, 0.2, and 0.4 mg L−1 of chlorpyrifos and 0, 0.005, 0.01, 0.015, and 0.02 mg L−1 of oxyfluorfen. The experiment was conducted in the plastic greenhouse where the temperature was regulated at 20 to 25 °C and a 16-h photoperiod was maintained. The different doses of pesticide were mixed with irrigation water and applied as overhead irrigation. After 3 months of pesticide application plants were compared for their growth by measuring growth index and biomass, and physical damage by visual scoring. Physiological differences were also compared by measuring gas exchange, light and dark-adapted chlorophyll fluorescence and chlorophyll content of leaves. The result shows, the damages to the plants were pesticide and species-specific. Oxyfluorfen had the greatest damage and the hydrangea was the most susceptible species. Chlorpyrifos and isoxaben never had any growth differences or visual deformities.

Specified Source(s) of Funding: PROJECT GREEN, MDARD

3:00 PM – 3:15 PM

Quantification of Paclobutrazol in Recirculated Water in Commercial Greenhouses

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Recirculation of irrigation water bears the risk of introducing residual concentrations of chemicals from overspray, runoff, and substrate leaching into water, which can reduce commercial quality of subsequent crops. Paclobutrazol is commonly used in the ornamental industry to regulate plant growth. Label concentrations for paclobutrazol application are lower for drench applications than foliar applications mainly because paclobutrazol moves in the plant through the xylem (bottom-up) and not through the phloem. Low concentrations of paclobutrazol in water applied via sub-irrigation systems can significantly reduce crop size. The objective of this project was to quantify residual concentrations of paclobutrazol in recirculated water in commercial greenhouses and determine potential risks of recirculating irrigation water. We collected
water samples from irrigation catchment tanks or ponds in commercial greenhouses dedicated to ornamental plant production and measured paclobutrazol using gas chromatography-mass spectrometry. Paclobutrazol levels were 30% higher in spring compared with autumn. Paclobutrazol levels in recirculated water across operations reached up to 77.2 ppb and 4.3 ppb in spring and autumn, respectively. Only one sampling time and location exceeded these values in spring (841 ppb). Our results suggest that there is a risk of undesired and uncontrolled growth reduction caused by residual concentrations of paclobutrazol in recirculated water in ornamental greenhouses.

Specified Source(s) of Funding: The Fred C. Gloeckner Foundation, Inc.

3:15 PM – 3:30 PM

Pesticide and Water Movement in Nursery Container Production: Managing Irrigation to Reduce Agrichemical Losses
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Nursery production is input intensive, demanding frequent irrigation and oftentimes multiple applications of pesticides throughout the season. Irrigation water lost to runoff or ground-water infiltration can move pesticides from production sites and contribute to non-point source pollution. Irrigation can be applied in ways which reduce runoff, such as incorporating micro-irrigation and sensor based technology. In this study, an experimental nursery was created with two 12 m (east to west) beds divided into eight sections each. The first 25 cm of the beds was backfilled with native soil and graded to the center and to the north or south side, covered with a pond liner, filled with 25 cm washed sand, graded as was the native soil, then covered with a landscape fabric as a production surface. Drainage ports were installed at the low points at the surface and at the subsurface pond liner and piped to collection tanks to collect water from runoff or infiltration. In 2017, three daily irrigation treatments, overhead at 19 mm, spray stake at 2 L per plant, or a set-point between 35% volumetric water content and container capacity, were used to determine water movement via runoff or infiltration. Three tank-mix pesticide applications were made at label rate and using industry standard practices. On 27 June acephate, bifenthrin, isoxaben and mefenoxam were applied; on 8 Aug. chlorpyrifos, triflumazol, oxyfluorfen, and glyphosate were applied; and on 29 Aug. prodiamine, glyphosate, and thiophanate methyl were applied. The water collected in each tank over a 24-h period was measured to determine concentration and load for nitrogen and phosphorus approximately every 2 weeks and on 0, 1, 2, 4, 8, and 16 days after pesticide application. The movement of each compound in water as a result of irrigation method yielded differences in concentration and load exported from production. Spray stake irrigation reduced total runoff and infiltration water quantity relative to overhead irrigation. Pesticides were detected primarily in runoff water but also occurred in infiltration water. Dynamics of water, pesticide and nutrient movement will be discussed during the presentation.

Specified Source(s) of Funding: SCRI WateR3

3:30 PM – 3:45 PM

Efficacy of Biofungicides to Control Pythium Root Rot and Damping-off in Hydroponically-grown Arugula
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Pythium spp. are the causal agents of Pythium root rot and damping-off in arugula (Eruca sativa) in hydroponic systems. Synthetic chemical fungicides are not registered for application in hydroponic solutions and few are registered for application on edibles in greenhouses. The objective of this project was to assess the efficacy of microbial biofungicides on Pythium root rot caused by Pythium spp. on arugula in hydroponic systems. Companion (Bacillus subtilis GB03), Triathlon BA (Bacillus amyloliquefaciens D747), or RootShield Plus (Trichoderma harzianum T-22 and Trichoderma virens G-41) were applied at label rate to germinated sprouts. One day after treatment, the plants were inoculated with Pythium spp. at 1 × 10⁵ zoospores per mL. After seven days, we measured root necrosis, disease incidence and severity, fresh and dry shoot, and root weight. All plants inoculated with Pythium spp. were smaller by 40.1% or more compared with non-inoculated plants. All plants treated with microbial biofungicides with or without Pythium spp. were smaller than the untreated control. Plants inoculated with Pythium spp. and treated with microbial biofungicides had lower disease incidence compared with the control. Root necrosis was lower in plants treated with Companion and RootShield Plus. Results from this experiment suggest that beneficial microbes can be introduced in nutrient solutions and reduce the negative effects of Pythium infection. Disease incidence and severity were reduced in most cases. However, plant growth was also reduced when microbial biofungicides were applied. Further research will be conducted to identify if lower microbial biofungicides rates or combined applications can reduce the negative effects of microbial biofungicides in plant growth.

Specified Source(s) of Funding: USDA via the Connecticut
Zoysia japonica

4:00 PM – 4:15 PM

Quantifying the Stormwater Ecosystem Services of an Urban Plaza with Mature Taxodium Distichum and Zoysia japonica

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We are monitoring green roof and urban tree systems in Washington, DC using wireless sensor networks for the continuous assessment of stormwater performance. One of these systems is at the U.S. Tax Court, where mature bald Cypress trees (Taxodium distichum) surrounded by zoysia grass (Zoysia japonica), are irrigated using runoff water collected from the roof and a hardscape plaza. The objectives of the study were provide daily and seasonal transpiration data for these two plant components, to understand how efficient this urban landscape is in mitigating the cost of potable water for irrigation, and additionally reducing stormwater drainage (impervious) fees, by quantifying the total runoff applied to this landscape on an annual basis. The tree/grass system is planted in a concrete overpass over the U.S. 295 highway that passes underground at that location. Ten replicate Cypress trees and approximately 75 m² of zoysia are monitored using a combination of soil moisture sensors, flow meters and a number of environmental (weather station) sensors. Data are logged using EM50R radio dataloggers (Meter-Group, Inc, Pullman, WA) on a 5-minute basis, and transmitted to a computer and radio basestation on site. Data are then assimilated into a database and charted graphically using Sensorweb™ software (Mayim, LLC, Pittsburgh, PA). Real-time data are available to irrigation managers over the internet through a password-protected site. Sensor data provide daily rainfall and irrigation inputs, reference evapotranspiration (ETo), and estimated daily crop water use (ETc), from soil moisture (Kc) data at three depths, integrated using the Penman monteith and a water balance model. During 2015, the water use of the cypress trees totaled 127,213 L compared to 47,438 L for zoysia. During 2016, the water use for cypress vs. zoysia was 152,496 and 61,737 L, respectively and 66,806 and 76,482 L from Apr.–July 2017. The total value of Stormwater Retention Credits based on the variable contract price in Washington, D.C., was $20,924, $46,285, and $128,757 for 2015, 2016 and 2017 respectively.

4:15 PM – 4:30 PM

Remediating Pesticides from Water through Biological Degradation and Adsorptive Mechanisms

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An asterisk (*) following a name indicates the presenting author.
An asterisk (*) following a name indicates the presenting author.

**Oral Presentations**

**Sujeet Verma***
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Pesticides subject to runoff from agricultural production contribute to non-point source pollution, where the effects on human and ecosystem health are of concern. Treating agricultural effluent prior to off-site discharge, or for recycling as irrigation, stands to benefit the environment and increase the sustainability of plant production. Agrichemicals can be remediated from water through microbially-mediated breakdown, as well as through sorption. In this study, a two-stage treatment system was constructed combining both processes, with water being provided at a consistent flow-through rate of 1.3 L/minute for a total of 625 L/day. Woodchips served as a carbon substrate in the first stage to allow the proliferation of denitrifying and pesticide degrading microbial communities, while a calcined shale product was used in the second stage as the sorptive medium. Simulated runoff containing representative amounts of fertilizer and pesticides were supplied to the treatment systems, with influent and effluent concentrations measured at each stage. Initially an incubation period with influent containing only nutrients (20 ppm nitrate, 3 ppm phosphate) was provided to allow development of microbial populations prior to incorporation of three pesticides, oxyfluorfen, chlorpyrifos, and bifenthrin at rates between 1 and 2 ppb. At critical stages throughout the study, the microbial communities in the treatment systems were isolated and comparisons were made between the consortia found in the nutrient only and the nutrient and pesticide treatments. Throughout the course of the study, effluent contents were monitored to determine the effects on the microbial communities and the saturation point of the sorptive materials. The remediation potential of nutrients and pesticides by these treatments will be presented, as well as population shifts in microbial communities throughout the study.

**Specified Source(s) of Funding:** WateR3, Project GREEEN, MDARD (Michigan Department of Agriculture and Rural Development)

**Fruit Breeding 1**

**Moderator:** Sujeet Verma
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4:15 PM – 4:30 PM

**Genomic Selection for Complex Traits in Strawberry Breeding at the University of Florida**

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Variable temperature and humidity in central Florida provide challenges for maintaining fruit quality and disease-free con-
ditions in strawberry (*Fragaria xananassa*) production. The present study investigates the genetic architecture of resistance to charcoal rot (CR) caused by *Macrophomina phaseolina*, anthracnose fruit rot (AFR) caused by *Colletotrichum acutatum*, and fruit volatile compounds in the University of Florida (UF) strawberry breeding program. Clonal replicates of more than 1100 seedlings from 73 full-sib families were control-inoculated with *M. phaseolina* during two consecutive growing seasons in Florida, and clonal replicates of more than 700 seedlings from 38 full-sib families were controlled inoculated with three isolates of *C. acutatum*. In addition, five crosses were evaluated for fruit volatile compounds. Phenotyping of disease resistance was conducted weekly, rating plant collapse for CR and fruit incidence for AFR. Population-wide volatile metabolomics were generated via SPME-GC/MC with statistical alignment via Metaling software for flavor compounds. Genotyping was performed using IStraw90 and IStraw35 SNP arrays. A pedigree-based analysis was performed for genome-wide QTL detection using FlexQTL™. Two major-effect loci, FaRMp1 and FaRMp2, on linkage groups (LG) 2AII and LG 4B, together explained 58% of the phenotypic variation in mortality due to CR; a single large-effect locus, FaRCa1, for AFR on LG 6B explained 51% of phenotypic variation for AFR incidence; and a major QTL for Linalool along with several other moderate-effect QTLs for other flavor compounds were detected. Validation of these loci may facilitate development of marker-assisted breeding tools and techniques for these traits.

4:45 PM – 5:00 PM

**Identification of QTLs for Phenological Traits in Peaches**

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Phenological traits of peaches (*Prunus persica* L., Batsch) are important for breeders to evaluate the adaptability in various environments and for the grower to efficiently manage their commercial orchards. Pedigree-based analysis (PBA) using Visual FlexQTL software was conducted on a total 162 individuals (143 F₉ seedlings and 19 founders and parents) grown in four environments (CA 2011, CA 2012, TX 2012, and TX 2013). A 9K SNP Illumina array was used for the genotyping. The objective of this study was to identify and compare quantitative trait loci (QTL) for three phenological traits including days to bloom (DTB), ripe date (RD), and fruit development period (FDP).

The results showed that twenty-one QTLs were mapped for the three traits with strong [2ln(BF) > 5] to decisive [2ln(BF) > 10] evidence across the four environments of phenotypic evaluations. Four QTLs were located on linkage group (LG) 1, and two QTLs were on each LG4, and LG7 for DTB. Six QTLs were identified on LG4 for RD. Lastly, six QTLs were found on LG4 and one on LG6 for FDP. QTLs on LG4 for FDP in TX 2012 and CA 2012 were co-localized, and both overlapped with RD in TX 2013 and CA 2012. The proportion of phenotypic variance explained (PVE) by a QTL for the three traits ranged from 18.5 to 95.4%. These results of identifying QTLs for these traits have validated QTLs that were previously reported in other breeding programs. This study would help peach breeders to develop DNA marker test and enable implementing marker-assisted breeding for developing new peach cultivars.

5:00 PM – 5:15 PM

**Mapping QTLs for Peach (*Prunus persica*) Leaf Resistance to Bacterial Spot [*Xanthomonas Arboricola pv Pruni* (*Xap*)] and Determining the Diversity and Virulence of a United States *Xap* Collection**

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Bacterial spot, caused by the bacterium *Xanthomonas arboricola pv. pruni* (*Xap*), is a threat to the plum (*Prunus domestica* L.), cherry (*P. avium* L.), and peach (*P. persica* L.) industries. This disease causes premature defoliation, reduced vigor and productivity, and yield loss due to unmarketable fruit in peaches grown in humid regions around the world, including the Eastern United States. Recommended cultural practices to control *Xap* include removal of infected tissue and application of bactericides containing a mix of copper and oxytetracycline. The development of bacterial spot resistant peach cultivars could help to mitigate the environmental and health risks of bactericides while reducing input costs for growers. Because *Xap* pressure varies from year to year depending on environmental conditions and disease incidence is low in some important breeding sites, molecular markers associated with bacterial spot resistance can help breeders to develop resistant cultivars efficiently. Markers for fruit resistance to bacterial spot have been developed from quantitative trait loci (QTL) discovered on linkage groups (LG) 1 and 6 as part of the RosBREED project and are currently used in the University of Arkansas System Division of Agriculture (UA) and Clemson University peach breeding programs. However, no markers associated with foliar resistance to bacterial spot have been developed. Seven populations and their parents (n = 210), were evaluated for fruit and foliar resistance in 2017 as part of a genome-wide association study (GWAS). Phenotypic data included visual ratings of fruit and leaves infected with natural inoculum at the UA Fruit Research Station in Clarksville, AR and a detached leaf bioassay performed in the lab under sterile conditions.
All individuals were genotyped with 16K peach genotyping array and GWAS was performed using a Q+K model. Foliar resistance was quantitatively inherited and controlled by several small-effect QTL located on chromosomes 1, 3, 4, 6, and 8, each explaining 5 to 15% of observed phenotypic variation. Only one QTL for fruit resistance was found on chromosome 5 in a position overlapping with the IndelG locus controlling fruit pubescence. Several of the populations evaluated contained both peaches and nectarines, and nectarines had more severe fruit symptoms on average. This experiment will be repeated for a second year during 2018.

Specified Source(s) of Funding: RosBREED

5:15 PM – 5:30 PM

**Fruit Quality Trait Locus Genotypes in Apple from Rosbreed’s SNP Array Data**

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Breeding done by today’s apple breeders has been greatly improved by DNA-informed breeding techniques, such as marker-assisted selection. Marker-assisted selection uses DNA-based markers to identify parents and seedlings that have favorable allelic combinations. DNA-based markers are locus-specific tags that reveal polymorphism in DNA sequences. Markers are available for a range of traits including biotic stress resistances, productivity, and fruit quality. For efficiency in marker-assisted seedling selection, trait-predictive markers are usually run a few at a time on families as “DNA tests”, but genetic information about parents is needed first. SNP arrays have become a preferred platform for elite germplasm (cultivars, collection accessions, parents and selections). SNP arrays can provide much more genetic information on germplasm individuals than each DNA test is able to. Currently, SNP data in apple do not automatically provide trait locus genotypes, thus translation of SNP data into haplotypes that are associated with each trait locus allele is needed. This study aimed to associate SNP haplotypes with alleles of fruit quality trait loci of apple, as part of the RosBREED project. Haplotype analysis revealed that overlapping QTLs for SSC, TA, and pH in the 2012 season were mapped to LG 6. Separate overlapping QTLs were identified for SSC, TA, and pH in the 2012 season and the QTL was confirmed across numerous generations and families. Allelic combinations of each germplasm individual were determined. This information enables breeders to understand the sources of alleles in their germplasm and efficiently reveals the genetic value of each breeding individual.

Specified Source(s) of Funding: RosBREED

5:30 PM – 5:45 PM

**Quantitative Trait Loci for Fruit Quality Attributes and Cold Hardiness in Muscadine Grape**

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John Clark
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Muscadine grapes, *Vitis rotundifolia* Michx. subgenus *Muscadina* Planch. (2n = 40), are a disease-resistant specialty crop native to the southern United States. Large berries, balanced fruity flavor, dry picking scar, and cold hardiness are important breeding objectives of the University of Arkansas fresh-market muscadine breeding program. The development of predictive marker-assisted selection methods for these traits would assist breeders in planning crosses and selecting promising seedlings early in the breeding pipeline. The objective of this study was to identify quantitative trait loci (QTL) for fruit quality attributes in two F<sub>2</sub> muscadine populations (‘Supreme’ × ‘Nesbitt’ and ‘Black Beauty’ × ‘Nesbitt’) segregating for many important traits. Ten mature berries were harvested from 172 progeny in each mapping population and evaluated for berry weight, soluble solids content, pH, and titratable acidity at the University of Arkansas Fruit Research Station during 2011 and 2012. The proportion of berries in each sample with a dry picking scar was recorded during the 2011 season. The severity of winter injury to each vine was visually assessed on a 1–5 scale during June 2017, after low temperatures dipped below –10 °C on four nights during Dec. 2016 and Jan. 2017. A high-density consensus linkage map consisting of 2346 markers in 20 linkage groups (LG) with a total length of 2164 cM was created using genotyping-by-sequencing (GBS) data from both populations. Quantitative trait loci were identified by analysis of traits combined over populations based on the consensus map. A large effect QTL explaining 15 to 30% of variation for berry weight in each population during 2011 and 2012 was mapped to LG 2. This QTL co-localized with the muscadine sex locus, with pistillate progeny producing larger fruit on average than perfect-flowered progeny. Overlapping QTL explaining 9 to 16% of variation for soluble solids content, titratable acidity, and pH in the 2012 season were mapped to LG 17 and explained 10 to 16% of trait variation. Three QTL for dry picking scar were found on LGs 3, 6, and 11, with the largest effect QTL on LG 6 accounting for 22% of trait variation in the ‘Supreme’ × ‘Nesbitt’ population. A QTL explaining 10 to 16% of variance in cold hardiness was also mapped to LG 6. The saturated linkage maps and QTL reported here lay the groundwork for marker-assisted breeding in muscadine grapes.

Specified Source(s) of Funding: Southern Region Small Fruit Consortium, SRSFCC Project # 2012-02.
Nursery Crops and Floriculture:
Diseases, Insects, Breeding and Taxonomy

Moderator: Michael Schnelle
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4:00 PM – 4:15 PM

Neonicotinoid and Pymetrozine Residues and Affects on Bees
Vera Krischik*
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Neonicotinoid residue in greenhouse plants may alter bee behavior. Imidacloprid residues in pollen of *Ruellia* at 5 weeks (267 ppb) decreased 50% by 10 weeks (125 ppb); *Calibrochoa* at 5 weeks (492 ppb) decreased 80% by 10 weeks (96 ppb); and dinotefuran residue at 5 weeks (748 ppb) decreased 88% by 10 weeks (96 ppb). These levels may alter survival or behavior in bees. Pymetrozine (Endeavor) residue at 5 weeks (126 ppb; 1/9) decreased 100% by 10 weeks and its use will reduce insecticide exposure to bees. These data support the FOE Gardeners Beware reports that showed 62% of purchased plants can contain neonicotinoid residue (2–879 ppb).

Specified Source(s) of Funding: MNLA MN nursery landscape association + MN sate funds

4:15 PM – 4:30 PM

Battling Rose Rosette Disease in the Great Plains
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Rose rosette disease (RRD) was first reported in the United States in 1940. Since then, the disease has become widespread east of the Rocky Mountains particularly with the advent of free-blooming cultivars that landscapers utilize in virtually every project. Even though the causal agent was identified in 2011 and a better understanding now exists of the eriophyid mite that transmits the rose rosette virus, RRD is still rampant and thus responsible for thousands of dollars in losses to producers, landscapers and ultimately, end consumers. The disease is readily spread through movement of the mite by crawling, wind, or through human-induced physical movement of the mite. Consequently, rose trials were initiated at Oklahoma State University and Kansas State University in 2016. Researchers hope to find commercially available rose cultivars that possess RRD resistance. These selections will be presented to rose breeders for consideration in future breeding programs. In addition to cultivar trials, best management practices are being studied in order to slow progression of this disease. Third year results of rose rosette disease incidence will be reported.

4:30 PM – 4:45 PM

Industry Typos in Plant Nomenclature: The Case of Zinnia Tenuifolia
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*Zinnia peruviana* L. is a flowering annual native to Central America. An interesting characteristic about this species is that it is the only member of the genus *Zinnia* that is self-compatible except for a popular cultivated Zinnia known as *Zinnia tenuifolia* ‘Red Spider’. Curiously, there is no published literature of the discovery of *Zinnia tenuifolia* even though it is listed as a species in seed catalogs. *Zinnia peruviana* was first introduced into cultivation by Phillip Miller, who brought seeds back to England in 1753. It was subsequently described as *Chrysogonum peruvianum* by Carl Linnaeus. Linnaeus later changed the name to *Zinnia pauciflora* L., but this name has since been reduced to a synonym of *Zinnia peruviana*. In 1755, the director of the botanical garden in Vienna, Nikolaus Joseph von Jacquin, was commissioned by Francis I of Austria to undertake a plant expedition to Central America. He returned in 1759, with a number of plant species, including seeds of a wild *Zinnia* species that he described as *Zinnia tenuiflora* Jacq. This name was later reduced to synonymy beneath *Zinnia peruviana*. Today, many seed companies employ various scientific names for *Zinnia* ‘Red Spider’, including *Zinnia tenuiflora*, *Zinnia tenuifolia*, and *Zinnia peruviana* syn. *tenuifolia*, but the most common name used in seed catalogs is *Zinnia tenuifolia* ‘Red Spider’. Considering the lack of a published protologue, the most likely origin of this name is a repeated industry typo of *Zinnia tenuiflora*, where ‘flora’ was changed to ‘folia’ to produce *Zinnia tenuifolia*. To test this hypothesis, we compared accessions of *Zinnia peruviana* obtained from the USDA Ornamental Plant Germplasm Center to commercially obtained seed of *Zinnia tenuifolia* ‘Red Spider’ for leaf dimensions, floret size and color, plant height, and internode length. ‘Red Spider’ had similar plant and flower morphology to the *Z. peruviana* accessions, and all were self-fertile. A cDNA analysis also revealed a great degree of similarity between *Zinnia peruviana* and *Zinnia tenuifolia* ‘Red Spider’. Based on these results, *Zinnia tenuifolia* ‘Red Spider’ should be considered a selection of *Z. peruviana* and not a distinct species.

An asterisk (*) following a name indicates the presenting author.
Floral and Plant Growth Characteristics of Zinnia peruviana Germplasm As a Potential Source of New Zinnias Varieties for Home Gardens

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The only variety of Zinnia peruviana L. that is available commercially is ‘Red Spider’. To determine whether other germplasm of potential commercial interest exists within this species, we evaluated 12 accessions of Z. peruviana obtained from the USDA Ornamental Plant Germplasm Center and compared them to ‘Red Spider’. Six plants of each accession were grown in the greenhouse and evaluated for plant height, internode length, and leaf shape. The flowers were evaluated for floret ray shape, size and color, and number of ray florets per flower. A subset of the accessions were also evaluated in the field for disease resistance compared to ‘Red Spider’ and other commercial zinnia varieties. Although the Z. peruviana accessions evaluated in this study had similar plant and flower characteristics typical of the species, significant differences were found among accessions for plant height, flower size, and floret color. No significant differences were found among Z. peruviana accessions for powdery mildew and bacterial leaf and flower spot disease ratings in the field, although their overall scores for disease development were lower than that of other commercial Zinnia violacea varieties. Some accessions of Z. peruviana showed potential as new zinnia varieties and it is recommended that further studies be done on their commercial value as cut flower and home garden types.

Impact of Acibenzolar S-Methyl, A Systemic Acquired Resistance Inducer, on Roses and Rose Rosette Disease Severity

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Commercial roses are susceptible to many viral diseases including rose rosette disease and rose mosaic virus disease. Between these two diseases, rose rosette disease is currently a major issue in the U.S rose industry. Rose rosette disease symptoms often appear as leaf distortion, rapid elongation of the branches, severe thorn proliferation, flower mutation, decreased vigor, and death of the plant. Currently, there are no effective methods for reducing the severity of rose rosette disease. Improving host resistance using a plant systemic acquired resistance (SAR) inducer is a potential management strategy, but needs to be evaluated against rose rosette disease. Acibenzolar S-methyl (ASM, Actigard) is a SAR inducer that activates the host plant’s salicylic acid pathway that stimulates plant immune defense mechanisms. The objectives of the study were to evaluate the effect of ASM on plant growth and development under commercial field nursery conditions, and to assess the effect of ASM in reducing rose rosette disease severity under greenhouse conditions in the absence of the insect vector (eriophyid mite). In 2016, two cultivars of Rosa L., ‘Radtkopink’ (Pink Double Knock Out®) and ‘Meijocos’ (Pink Drift®) (N = 160), were treated weekly for 12 consecutive weeks with foliar applications of ASM at three rates (0.5, 0.75 and 1.0 oz/A). Continuous weekly applications of ASM at even the highest rates were never fatal to any individual of either rose cultivar. Flowering of either rose cultivar was unaffected by ASM treatment (P = 0.05). Other plant parameters were also studied and will be reported. In general, this study has shown ASM is safe for use on roses undergoing containerized nursery production. Foliar application of ASM at 50 mg/L and 100 mg/L significantly reduced rose rosette disease severity compared to the untreated control in two of the three greenhouse trials (SNK, P = 0.05). Based on this information, field studies on the impact of ASM to reduce rose rosette disease severity will be a top priority for ongoing research.

Specified Source(s) of Funding: Southern Region IPM

Long-lasting Protection: Preventing Ambrosia Beetle Attacks Using Insecticidal Netting

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Exotic ambrosia beetles have been an important problem in ornamental and fruit tree production for decades. Due to their small size, wide host range and season-long period of activity, chemical control measures can be costly and unreliable. Alternate measures of control are needed to protect tree crops. Field trials were conducted in Mississippi, Virginia, Tennessee, Ohio, and South Carolina to determine how well a wrap of deltamethrin-treated net can protect flood-stressed trees from ambrosia beetle attacks. Treatments in 2017 included: 1) an unflooded negative control tree with no net, 2) flooded positive control tree with no net, 3) flooded tree with an untreated net, and 4) flooded tree with a treated net. In 2018, an additional treatment using a finer mesh size was tested with the aim of achieving greater control. In each year, trees were left along the edge of infested forests for ~1 month, after which counts of completed and abandoned beetle galleries were made along the length of the tree trunks. In 2017, while attacks were significantly lower on trees with treated net as compared with the other flooded trees, some beetles were able to crawl through the treated netting and complete gallery excavations. However, counts of abandoned galleries were significantly higher on the treated-net trees, representing beetles dying from insecticide exposure before they could complete galleries. New data from 2018 trials will be presented.

Enhancing the Salt Tolerance by Zinc Application in Gladiolus
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The aim of this study was to investigate the response of *Gladiolus grandiflorus* to zinc (2, 4, and 6 mg·kg⁻¹) application and various salinity levels (2, 4, and 4 dS·m⁻¹) of irrigation water. The analysis results of morphological and growth attributes of *Gladiolus* indicated significant reduction in the investigated attributes with increased in salinity, while zinc application alleviated the stress by increasing morphological and growth parameters. Furthermore, the study demonstrated that the continuous irrigation of saline water lead to a decrease in membrane stability index and relative water content, these were well-linked with reduction in the enzyme activity. Although soil application of zinc levels decreased the salinity stress, but the most pronounced results were obtained at low level of salinity (2 dS·m⁻¹) provided with different zinc doses (2–6 mg·kg⁻¹). It is concluded that soil application with zinc may have a potential role for increasing Gladiolus tolerance to salinity stress.

HortScience 53(9) Supplement—2018 ASHS Annual Conference
Containerized culinary herbs should be proportional to the container they are produced in so they are aesthetically balanced for marketing and sales. While anti-gibberellin plant growth retardants are commonly used to control containerized-plant growth, they are not labeled for use on containerized herbs and non-chemical growth-control strategies must be used. The objectives of our research were to quantify the impact of restricting irrigation on the growth and tissue nutrient concentration of basil (Ocimum basilicum L.), dill (Anethum graveolens L.), and parsley [Petroselinum crispum (Mill.) Fuss.], and common sage (Salvia officinalis L.). Seedlings were individually transplanted into 4.5-inch diameter round containers filled with a substrate comprised of (by vol.) 75% ground sphagnum peat moss and 25% coarse perlite and amended with 5 lb/yd³ controlled-release fertilizer. Plants were watered to container capacity at transplant, allowed to dry down to volumetric water content (VWC) thresholds of 0.15, 0.23, 0.30, 0.38 or 0.45 m³·m⁻³ and subsequently maintained at desired setpoints by using a precision irrigation system controlled by soil moisture sensors. Four weeks after seedlings after seedlings were transplanted and irrigation treatments began, data were collected on plant height and width, node number, leaf area, internode and branch length, chlorophyll fluorescence, photosynthesis, transpiration, and conductance. Shoots were harvested and dried for 3 d, after which mass was recorded. For all four species, plant was positively correlated with substrate VWC. However, magnitude of change in response to VWC varied with species. For example, height of basil increased from 24.6 to 29.2 cm (19% increase) as substrate VWC increased from 0.15 to 0.45, respectively. Alternatively, as substrate VWC increased from 0.15–0.45, height of parsley increased from 14.9–to 27.1 cm (82% increase), respectively. Other growth responses followed a similar trend. While conductance and transpiration were unaffected by substrate VWC, photosynthesis of basil and parley increased as substrate VWC increased. Similarly, chlorophyll fluorescence of basil, parsley, and sage were indicative of plants that were not stressed, regardless of substrate VWC. Based on the results of our research, restricting irrigation can suppress growth of containerized herbs. However, the magnitude of growth control varies with species and for some species, such as basil, restricting irrigation may not be sufficient as the sole approach to controlling growth.

**Specified Source(s) of Funding:** Fred C. Gloeckner Foundation

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**Goji Root Bark Quality Grown in Central Washington State**

Kevin Li

Amway Botanical Research Center, Wuxi, China

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**Restricting Phosphorous Suppresses Growth of Containerized Culinary Herbs**

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Chemical plant growth regulators (PGRs) are commonly used to control growth of containerized plants. However, commercial PGRs are not labeled for containerized culinary herbs and alternatively growth control strategies must be used. The objectives of our research were to quantify the impact of restricting P on the growth and tissue nutrient concentration of basil (Ocimum basilicum L.), dill (Anethum graveolens L.), and parsley [Petroselinum crispum (Mill.) Fuss.], and common sage (Salvia officinalis L.). Seedlings were individually transplanted into 4.5-inch diameter round containers filled with a substrate comprised of (by vol.) 80% ground sphagnum peat moss and 20% coarse perlite and adjusted to a pH of ~6.0 using calcitic limestone. Beginning at transplanting, plants were irrigated with nutrient solutions providing 0, 5, 10, 20, or 40 mg L⁻¹ P formulated from technical-grade compounds. The N concentration was 150 mg L⁻¹ and, along with all other macro- and micronutrients except for P, was consistent across all solutions. Four weeks after seedlings after seedlings were transplanted and P treatments began, data were collected on plant height and width, node number, leaf area and internode length. Shoots were harvested and dried for 3 d, after which mass was recorded and shoots were submitted to a commercial laboratory for tissue analyses. For all four species, plant height and width increased as P increased. However, the relationship between P concentrations and plant height was non-linear. As P concentration increased above 0 plant height increased until a maximum height was achieved height increases plateaued. Height increased for basil, dill parsley, and sage as phosphorous increased from 0 to 20 mg L⁻¹, but did not increase as concentration further increased to 40 mg L⁻¹. Restricting P applications to 5 mg L⁻¹ resulted in plants that were 12.0 cm (29%), 9.0 cm (32%), 4.6 cm (20%), and 6.7 cm (27%) for basil, dill, parsley, and sage, respectively. The effect of P on width followed a similar trend. In addition to height and width, restricting phosphorus also restricted branching and leaf expansion. While P concentrations that produced compact plants also resulted in tissue P concentrations that were below recommendation tissue concentration minimum values, visible P deficiency symptoms were not manifested. The results of this study illustrate that restricting P can suppress plant growth of containerized herbs, resulting in plants that are proportional to their containers and lack visible deficiency symptoms that may diminish retail marketability.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation

5:30 PM – 5:45 PM

Phenylalanine Boosts Brassica Production of Polyphenols for Medicinal Production

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Chronic pain caused by injuries or disease impedes performance, and also leads to anxiety, depression and disability. non-opiate, antiinflammatory painkillers need to be developed. Phenotypes of high polyphenol plants in the Brassicaceae have been developed from abiotic stimuli experiments. Vegetatively propagated lines of three plant species used in medicinal or nutraceutical treatments were screened for polyphenol production in specific cell types. Analytical chemistry has permitted identification of polyphenol and other constituents in vegetative material. Polyphenols administered to mice reduce inflammatory pain responses. Analysis of chemical stability indicate specific solvents and concentrations affect shelf life and mode of administration. Analysis of seeds and seedlings indicate selection criteria based on polyphenols may speed production of useful pharmaceuticals.

5:45 PM – 6:00 PM

Influence of Saline Water Irrigation on Cilantro (Coriandrum sativum L.) under Drought Stress

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Cilantro (Coriandrum sativum L.) is a medicinal and aromatic plant that is widely used around the world. However, little research has focused on cilantro’s responses to abiotic stress. Our objective was to quantify interactive effects of drought and salinity on growth, photosynthesis, and mineral content of cilantro. Plants were irrigated with water with four salinity levels (0, 50, 75, 100 mM NaCl) and exposed to three levels of drought (100% (control), 80% (mild drought) and 40% (severe drought) of the water required to reach container capacity). The study was conducted inside a greenhouse. The water content of the growing media was measured before each irrigation event (WET-2 sensor) and the applied water amounts were recorded to determine irrigation water use efficiency (IWUE, fresh weight/irrigation water use). Increasing salinity levels reduced yield and decreased all gas exchange and vegetative growth parameters. Although the highest yield was obtained from the control treatment, the highest IWUE was found under severe combined stress conditions. Severe drought stress reduced yield by ~30% and 100 mM NaCl reduced yield by ~60% compared to the control treatment, while their combination decreased yield by ~70%. Drought and salinity treatments affected fresh
weight more strongly than dry weight, suggesting that yield effects were partly due to differences in plant water content among treatments.

**Commercial Horticulture 1**

*Moderator:* Stephen S. Deschamps  
University of Florida, Wimauma, FL, USA

4:45 PM – 5:00 PM

**Nitrogen Affects the Growth and Yield of Day-neutral Strawberry ‘Albion’ in Low Tunnels**

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Strawberry (*Fragaria xananassa*) is a major component of North Carolina agriculture, Strawberry production in the state ranks fourth in the United States, with a total of 2000 acres in production. Traditionally, the North Carolina strawberry season only has a five to seven-week harvest period that begins in April. Most of the berries produced are grown in an annual plasticulture system with several June-bearing cultivars. Strawberries have proven to be economically sustainable in North Carolina and are popular with consumers year-round. The objective of this study was to investigate if growth and yield will be enhanced by increased nitrogen levels for day-neutral cultivars, paired with low tunnels targeting both fall and spring harvests. In Fall 2017, research was conducted at the Sandhills Research Station (Jackson Springs, NC) with the day-neutral cultivar Albion. Plugs were planted in standard plasticulture system with low tunnels installed over the beds. The experimental design was a completely randomized design with three replications. Treatments included a single broadcast preplant dry application (60 lb/acre) and eight weekly drip-applied applications (0, 3.5, 7, and 10 lb/acre). There were substantial interactions in both plant growth and yield with increased nitrogen rates. Market yields were maximized with total nitrogen at 140 lb/acre with 60 lb/acre applied preplant as a broadcast granular and 80 lb/acre applied through fertigation for eight weeks, beginning at first bloom. Yield ranges were 0.092, 0.131, 0.137, and 0.168 lb/plant, yield increase was consistent with increased nitrogen; however, tissue analyses with leaf petioles showed that there was no significant difference in terms of NO3-N between treatments. Biomass of crowns, leaves, and roots increased with nitrogen rate similar to the market yield. Our preliminary results suggest that growers can get a reasonable fall yield from day-neutral cultivars grown under low tunnels and fed at a relatively higher nitrogen rate.

5:00 PM – 5:15 PM

**Strip Planting Cover Crops to Improve Performance of Zone Tilled Organic Vegetables**

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Ryan Maher  
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Reduced tillage systems for vegetables must provide good crop establishment, soil temperatures, moisture and fertility to support desired quality, yields and timeliness of harvest. In more northern climates, zone tillage vegetable systems have shown to balance some of the soil improving benefits of no-till with the well-known advantages of tillage. However, zone tillage must overcome multiple barriers to grower adoption, including high weed pressure, interference from surface residue, and low soil nitrogen (N) availability. Strip planting legumes (in-row) and winter rye (between-row) could advance zone tillage systems for summer transplants by concentrating low residue, high nitrogen in the tilled zone while maintaining high-residue, weed suppressive mulch between-row. Over four site-years, we have investigated the effects of overwintering legume cover crops (none, hairy vetch or crimson clover) grown in mixture with cereal rye on N availability, weed suppression, and crop yield in an organic strip-tilled cabbage system. Cover crops were planted in the fall at two locations (NY and MI) in both mixes and alternating strips of legume and rye. In spring, cover crops were then managed by flail mowing, retained on soil surface and zone tilled. We measured cover crop biomass and total N and C:N ratio, weed biomass prior to planting, soil inorganic nitrogen at planting and during crop growth, and weed biomass at harvest and crop yield. Supplemental sidedress N was applied to subplots for each treatment. Winter rye–vetch mixtures had similar total cover crop biomass and total N compared to crimson clover but significantly lower C:N ratio. Optimizing cover crop termination with mowing was challenged by differences in species maturity; crimson clover was terminated later than ideal, since mowing had to match cereal rye anthesis. Strip planted cover crops facilitated zone-tillage by minimizing residue in the zone. Strip planting did not, however, result in yield improvements compared to mixed cover crop planting. Sidedress N provided slight improvement in yield within each cover crop treatment, but did not change ranking of the cover crops.
Oral Presentations

5:15 PM – 5:30 PM

Developing Adzuki Bean and Quinoa in Irrigated Fields of Eastern Oregon

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In Eastern Oregon, potatoes and onions are the main high-value crops, which can only be planted every 2–3 years in rotation. Other rotational crops, such as wheat and corn, have endured low commodity prices for the past several years, thus growers’ profits are marginal. Therefore, there is a need to increase the rotational crop choices, especially with higher value crops, to increase growers’ profits. In fields with Adkins fine sandy loam at Hermiston, Oregon, we conducted field trials to evaluate the possibility of developing adzuki beans and quinoa, which have great marketing potential. One adzuki bean variety and two quinoa varieties were tested. All the crops were grown under two irrigation systems, i.e. central pivot and drip irrigation. For adzuki beans, four fertilization treatments including low-nitrogen rate, high nitrogen rate, manure, and no-fertilizer control with four replicates were studied as in-season fertilization. The first-year results showed that adzuki bean could be a suitable crop for the region, while quinoa failed to produce seeds. The drip irrigation showed great advantages in promoting the crop growth and/or production. The impact of fertilizer was not apparent for the adzuki bean. Further studies are needed toward selecting proper varieties and developing best crop management practices in order to realize the successful crops and ideal production in this region.

5:30 PM – 5:45 PM

Characterization of Microenvironment Optimization by Multi-colored Plastic Mulch for Winter Strawberry Production in Florida

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Vance Whitaker
University of Florida, Wimauma, FL, USA
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University of Florida, Wimauma, FL, USA

The strawberry production season in Florida and many other winter production regions is characterized by excessive heat during fall establishment and cool, sometimes freezing, temperatures during peak production. To mitigate seasonal temperature extremes, new plastic mulch films that are white or metalized in the center and black on the shoulders have been recently developed. Our previous studies demonstrated that these striped plastic mulches improve fruit earliness, allowing growers to advance planting dates from October to September by reducing heat stress during transplant establishment. To characterize microenvironment modification by striped plastic mulches, we monitored several soil and canopy microenvironment variables during the 2017–18 winter strawberry growing season in Balm, FL. We evaluated entirely black plastic mulch (black mulch) against black plastic mulch with either a 51-cm wide white or aluminum center stripe (white-striped and metalized-striped mulch, respectively), using the short-day cultivar ‘Florida Radiance’. Bare-root transplants were established in raised beds on 28 Sept. 2017. Thirty harvests were performed from mid-November through February. White-striped and metalized-striped mulches increased the early-season marketable yield by 40% and 52%, respectively, and the total season marketable yield by 26% and 34%, respectively, confirming the beneficial effects of these mulches on strawberry yield and earliness. Root-zone temperatures measured at a 10-cm depth under both striped mulches were reduced by 3 °C compared to black mulch throughout the hot afternoons of October and November. For the same time periods, crown tissue temperatures monitored over the striped mulches via a fine-wire thermistor showed a reduction of up to 2 °C compared to black mulch. Spectroradiometric measurements in the late season showed that even within a well-shaded canopy, photosynthetically active radiation reflected by the mulch surface increased by 349% for white-striped mulch and 302% for metalized-striped mulch compared to black mulch. Spectroradiometric measurements also showed that, compared to black mulch, white-striped mulch decreased the ratio of red to far-red light within the canopy, which may play a role in floral bud induction for short-day strawberry cultivars. In summary, the changes in microenvironments with striped mulches can be characterized by cooler soil and crown temperatures during establishment, increased potential light capture, and far-red light enrichment. These results demonstrate that striped mulches optimize microenvironments to a comparable extent and serve as a feasible strategy to improve yield and earliness for winter and spring strawberry producers.

Specified Source(s) of Funding: Florida Strawberry Research and Education Foundation; Imaflex, Inc.

5:45 PM – 6:00 PM

Improving Establishment, Earliness, and Yield of ‘Florida Beauty’ Day-neutral Strawberry for Winter Production by Optimization of Early-season Nitrogen Fertilization and Plant Spacing

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Strawberry growers in Florida generally apply 168–224 kg of nitrogen (N) per hectare during the growing season, starting with 1.96–2.24 kg/ha/d during establishment followed by lower rates at 0.56–1.12 kg/ha/d. The initial high-dose fertilization

An asterisk (*) following a name indicates the presenting author.
The uses reported for this species include food purposes, ceremonial beverages and the treatment of disease. Mortiño berries are considered an exotic fruit with a high potential of consumption due to their content of anthocyanins, proanthocyanidins and polyphenolic compounds, which have shown to possess antioxidant and anti-inflammatory properties. Mortiño is classified as a vulnerable species by the IUCN due to the fragmentation of its habitat. This species has not been domesticated, and its limited propagation capacity has been reported. Probably because of this feature, no attempts to cultivate this plant have been successful. Therefore, biological and ecological studies are needed to implement conservation and cultivation strategies. Furthermore, understanding the interaction of the plant with the bacterial communities of the rhizosphere could contribute to its establishment and subsequent cultivation. In a previous study, we reported the genetic diversity of mortiño using 14 homologous microsatellites markers (SSRs) in nine localities from the provinces of Imbabura, Pichincha and Cotopaxi. For the present study, we have expanded the study area to 22 localities across 10 provinces of the Ecuadorian highlands, using 16 homologous SSRs markers in 85 individuals. Our results revealed a moderately high global genetic diversity (He = 0.75), with most of the diversity (71%) harbored within localities. The analysis of population structure showed three well-defined clusters in the Ecuadorian highlands, each including samples from different localities, suggesting gene flow between them. One exception occurs in the samples from Azuay, which grouped separately—indicating that this grouping could represent a specific gene pool. These results are the basis for our future research related to the identification of the core microbiota in the most genetically diverse individuals from different localities. Understanding the possible interactions between the plant species and its associated rhizosphere microbiota, along with the data of the genetic diversity of V. floribundum in Ecuador, could allow us to design conservation plans for this valuable genetic resource in the wild and to design programs for the development of sustainable agronomic systems.

An asterisk (*) following a name indicates the presenting author.
Transcriptional Regulation of Flower Senescence

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Genetic regulatory mechanisms that control natural flower senescence in petunia are not well understood. To identify key genes and pathways that regulate the process, we conducted a transcriptome analysis in petunia corolla at four developmental stages, including fully opened corolla without anther dehiscence (D0), two days after anthesis (2 DAA, fully expanded, D2), 4 DAA with initial signs of senescence (D4), and 7 DAA with wilting (D7). We identified large numbers of differentially expressed genes (DEGs), including 1116 between D2 and D4, a transition to the onset of flower senescence, and 327 between D4 and D7, a developmental stage representing flower senescence. KEGG analysis showed that the auxin- and ethylene-related hormone biosynthesis and signaling transduction pathways were highly upregulated at onset of flower senescence. Ethylene emission was detected at the D2 to D4 transition, followed by a large eruption at the D4 to D7 transition. Furthermore, large numbers of transcription factors (TFs) were activated over the course of senescence. Functional analysis by virus-induced gene silencing (VIGS) experiments demonstrated that inhibition of the expression of TFs, such as ethylene-related ERF, auxin-related ARF, bHLH, HB, and MADS-box, significantly extended or shortened flower longevity. Our data suggest that hormonal interaction between auxin and ethylene may play critical regulatory roles in the onset of natural corolla senescence in petunia.

5:15 PM – 5:30 PM

The Citrus Flowering Locus T (CiFT3) Gene Results in Precocious Flowering When Overexpressed in the Carrizo Citrange Trifoliate Rootstock

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The genus Citrus consists of a group of long lived perennial trees species that have a variable juvenile phase ranging from 3–15 years or more. Most commercially cultivated sweet oranges and mandarins have a juvenile phase of more than five years. The transition from juvenile to the adult stage is a complex process involving several genes of which the FLOWERING LOCUS T (FT) is crucial. The Citrus clementina CiFT3 gene was constitutively expressed under the control of a strong 35s promotor or a weaker NOS promotor. In addition, phloem expression of CiFT3 was controlled by the AtSUC2 promotor or the gene was induced under control of an Arabidopsis heat shock protein (AtHSP) promotor. Genetically transformed carrizo citrange explants expressing the 35S-CiFT3 resulted in precocious flowering in the apical meristems in vitro and subsequent death of the explant. Also, 25 transgenic lines expressing CiFT3 gene under the control of the AtHSP (11 lines) and NOS (14 lines) promoters did not flower even after five years following transformation. Additionally, 14 transgenic plants overexpressing CiFT3 gene constructs under the control of the AtSUC2 promotor were produced, four of which had more lateral branches than wild type and flowered within 16 months following transformation. There were no morphological abnormalities observed in the flowers and they produced viable pollen grains that resulted in self-pollinated seeds. The expression patterns of floral meristem identity genes indicated that AP1, FT, LFY and SOC1 were significantly upregulated in the transgenic lines that flowered. TFL was downregulated in the precocious transgenic lines. Propagation of the 4 transgenic lines either through tissue culture or through mistbed resulted in the production of a large clonal population. These transgenic plants exhibit normal vigor and do not have a problem of terminal dieback. Grafting with juvenile scions will be conducted to evaluate the suitability of these early flowering lines with the hope of enhancing flowering in juvenile citrus scions.
Plasticulture

Moderator: Annette Wszelaki
University of Tennessee, Knoxville, TN, USA

4:45 PM – 5:00 PM

Promoting Productivity and On-farm Efficiencies in Tissue Culture Red Raspberry System through Biodegradable Plastic Mulches

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Florican red raspberry (Rubus idaeus) in northwest Washington is traditionally grown in raised beds with weeds managed through a combination of herbicide applications and hand weeding. Tissue culture (TC) raspberry plantings are increasing in Washington due to the availability of new cultivars sold exclusively as TC transplants as well as traditional cultivars becoming available through TC. However, TC transplants are more difficult to establish and cost more than traditional root and cane planting materials; therefore practices that offset these higher establishment costs might be important for overall on-farm economics. The overall objective of this project is to develop knowledge and practical strategies to improve establishment of TC raspberry transplants through application of biodegradable plastic mulches (BDMs) prior to planting. Six treatments, including four BDMs, one non-degradable polyethylene (PE) mulch, and a bare ground (BG) control are being evaluated in a commercial ‘WakeField’ raspberry field planted May 2017 in northwest Washington. Crop growth, weed suppression, mulch performance [as percent soil exposure (PSE)], soil temperature and moisture, and root lesion nematode (Pratylenchus penetrans; RLN) population dynamics were measured in the 2017 season. By the end of the growing season (Oct. 2017), average primocane height and numbers were 36 cm and 5 canes/hill greater, respectively, in all mulched treatments relative to the BG control. Weed incidence was reduced in mulched plots compared to the BG control. No post-plant herbicides or hand weeding were applied to mulched plots, but hand weeding occurred three times in the BG control. PSE at the end of the year was lowest for PE (2%) and ranged from 48% to 72% in the BDM treatments. Soil temperature was on average 1.2 °C higher in all mulched treatments relative to the BG control. When volumetric water content was considered, PE

An asterisk (*) following a name indicates the presenting author.

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Impact of Flowable Liquid Lime on Soil pH When Injected through Drip Irrigation

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In the southeastern United States, many vegetable growers produce multiple crops over several years on plastic mulch in order to reduce input costs for the crops grown. Typically a high value crop such as bell pepper (*Capsicum annuum*) or tomato (*Solanum lycopersicum*) will be grown first, followed by lower valued crops such as squash (*Cucurbita pepo*) and even cabbage (*Brassica oleracea var. capitata*). One problem encountered is that there is no practical way to increase the soil pH in the planted bed for second or third crops. Generally limestone-based products are insoluble and not appropriate for injection through drip irrigation. Recently, a finely ground (<0.5 micron) liquid limestone based product (Top Flow 130; Omya, Oftringen, Switzerland) was developed for agriculture use to be injected through drip irrigation tubing. To test the efficacy of Top Flow 130, 0, 94, and 187 L·ha⁻¹ of product were injected through drip irrigation and soil pH and nutrient content evaluated 7, 17, and 28 d after injection. Soils tests were conducted using the Mehlich 3 extraction method. The study was arranged in a completely randomized design with four replications. Each plot was a plastic mulched bed approximately 24 m long. Flow rates measured before and after injection were not affected by treatment, suggesting that the liquid lime product did not clog emitters. There were significant interactions between application rate, sampling time, and distance from the emitter for change in soil pH and calcium level. In general, both application rates led to a significant increase in soil pH and calcium concentration at the emitter location and a distance of 10 cm from the emitter. Soil pH and calcium concentrations did not significantly change when measured at 20 cm from emitters. The increase in pH and calcium concentrations at a distance of 10 cm from the emitter were greater in those plots receiving 187 kg·ha⁻¹ compared to those getting 94 kg·ha⁻¹ of Top Flow 130. The effects on soil pH and calcium concentrations occurred within 7 d after injection of the product, with no significant differences occurring between the 7, 17, and 28 day sampling periods at each sampling location (0, 10 and 20 cm from the emitter). These results suggest that Top Flow 130 could be used to adjust pH in a plasticulture system, but that the effects would occur within a zone of 10 cm on each side of the drip irrigation tubing.

5:15 PM – 5:30 PM

Pepper Production on Biodegradable Mulches in the Southeast

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Plastic mulch has many benefits (e.g., weed and disease management, increased yield and quality, moisture conservation), but also several drawbacks (e.g., disposal cost, environmental concerns). Biodegradable plastic mulches (BDMs) offer a potential alternative if they can provide similar advantages to polyethylene plastic mulch without the disadvantages of additional labor costs for removal and disposal, contributing to landfills waste and polluting the environment. In a field experiment in 2017, we tested five potentially biodegradable plastic mulches (Experimental PLA/PHA, Organix A.G.: Black, Organix A.G.: White-on-black (WOB), Naturecycle and BioAgri), a creped cellulose mulch (WeedGuardPlus), polyethylene plastic mulch (non-biodegradable) and a no-mulch treatment for their effects on pepper (cv. Aristotle) petiole sap nitrate status, and fruit yield and quality. Additionally, weed assessments were conducted three times during the season (early, mid and late-season), and mulch degradation or percent soil exposure (PSE)- a visual rating of the amount of soil exposed due to mulch degradation- was measured twice monthly over the growing season. Petiole sap nitrate was lower in the white-on-black and paper mulches and bare ground plots at first flower and second harvest (range of 205–281 NO₃⁻N ppm for bare ground, paper and WOB, range of 577–775 NO₃⁻N ppm for the black mulches at firstflower). Total season yields for marketable number of fruit per plot ranged from 35.4 to 38.5 in bare ground, BioAgri, PE, WeedGuardPlus and WOB, but were lower in Exp. PLA/PHA, Naturecycle and Organix (27, 18.2, and 27.1 respectively), likely due to severe nutsedge pressure. Nutsedge penetrated all of the mulches, except WeedGuardPlus. The number of weeds per m² at the late season weed rating was only 12.1 for WeedGuardPlus and ranged from 37.1–84.2 for all other treatments. The quality parameters of color and soluble solids did not differ among mulch treatments. The paper mulch degraded more quickly than the other mulches and very little, if any, of the mulch could be seen by the end of the season (PSE 100% for WeedGuardPlus, other treatments ranged from PSE of 15% for PE up to 69% for Naturecycle). In spite of this degradation, WeedGuardPlus generally stays intact during the critical weed period (first 4–6 weeks after planting) until the plant canopy fills in, providing nearly season long weed control. With this in mind, it is important to consider the most important benefits to be gained from the BDM before choosing a product.
Life under Plastic; It’s Fantastic: Wavelength-selective High Tunnel Plastic for Controlling Two Insect Pests in Primocane Fruiting Red Raspberry

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High tunnels are an increasingly important technology in raspberry production. They protect the crop from rain and low temperatures, lengthening the growing season and improving fruit quality. As high tunnels have become more common, the number of materials available for covering tunnels is increasing. New plastics which block or alter natural sunlight provide growers with options. Some plastics block wavelengths in the ultraviolet and infrared ranges while others diffuse light, scattering it as it enters the tunnel. Polarized and ultraviolet light are used by many insects in navigation. Previous research showed that insect pest populations of several different orders are reduced when greenhouses are covered with ultraviolet (UV)-blocking plastics. Meanwhile, anecdotal observations indicate that Japanese beetles (Popillia japonica) are less problematic in high tunnels than in field-grown raspberries. For these reasons, we investigated the effects of various plastics on two key pests of red raspberries, Japanese beetle and Spotted Wing Drosophila (Drosophila suzukii, SWD). Research was conducted in 2016 and 2017. We grew two cultivars of primocane red raspberries, 'Polka' and 'Josephine' in high tunnels with five different plastic coverings plus an uncovered control. All plastics blocked some portion of the ultraviolet and visible range, and one also blocked infrared light. Japanese beetles were removed by hand and counted every day in 2016, and every five days in 2017. The SWD were monitored with vinegar traps and harvested fruit were incubated to observe emergence of the flies. Foliage temperatures were measured with an infrared thermometer twice during the summer in each tunnel on the east and west sides of the rows. Fruit was harvested three times per week. Mean and cumulative beetle counts were compared for the different plastics, dates, and cultivars. Mean and cumulative trap counts and infestation rates for SWD were compared for the different plastics, dates, and cultivars. Weekly yield, and temperatures were compared between treatments and used as covariates. All plastics significantly reduced Japanese beetles. UV-blocking plastics had the lowest numbers, while the partially UV-blocking plastic which blocked some IR, was not significantly different from the non UV-blocking plastics in 2017. In contrast, SWD trap numbers were lowest in tunnels that transmitted UV-light in 2017, and highest in those that blocked it. This suggests that SWD do not need UV in order to navigate, and may favor environments without it.
The objective was to determine the effect of substrate moisture content (SMC) during poinsettia (Euphorbia pulcherrima ‘Christmas Eve Red’) greenhouse production on plant quality, postproduction longevity and economic value. Treatments included two SMC levels (20% or 40%) applied in four timing of application combinations. Total production (TP) time was 12 weeks in which vegetative production (VP) occurred from week 35 to 39 and reproductive production (RP) continued from week 40 to 47. Four timing of application treatments: 40/40 = TP at 40% SMC; 20/40 = VP at 20% + RP at 40%; 40/20 = VP at 40% + RP at 20%; 20/20 = TP at 20% SMC. After 12 h simulated shipping in the dark, plants were evaluated for two weeks in a simulated retail environment with two packaging treatments: no packaging or plastic perforated plant sleeves. Growth index (GI), light intensity within the plant canopy and ethylene concentration were measured during postproduction. Water potential was reduced in week 40 with 40/20 treatment only. At the end of greenhouse production, plants grown in 20% SMC during RP (20/20 and 40/20) had shorter bract internode length, stem length and smaller GI, and decreased shoot and root DW, and bract and leaf area compared to those in 40% SMC during RP (40/40 and 20/40). Poinsettias grown in 40% SMC had higher Pn than those in 20% SMC regardless of production stage. Leaf thickness, petiole thickness, bract and leaf number were not affected by SMC treatments. Plants in 20/20 or 40/20 had earlier bract coloring despite days to anthesis being the same for all SMC treatments. Compared to 40/40, 40/20 and 20/20 could save 44.2% or 43.6%, respectively, on irrigation and fertilizer usage, and 39.1% and 35.0%, respectively, on labor time. During postharvest, ethylene concentration was not affected by packaging method. Sleeved plants had lower light intensity in the plant canopy causing plants to have greater necrotic stem numbers and lower visual ratings at the end of postproduction. The 40/40 sleeved plants had increased yellow leaf and necrotic stem numbers. In summary, reducing SMC to 20% during total production or during the reproductive stage reduced water usage and produced more compact plants with greater postproduction quality.

An asterisk (*) following a name indicates the presenting author.

Oral Presentations

8:15 AM – 8:30 AM

Effect of Production Fertilizer Concentration on ‘Pretty Grand Red’ Petunia Growth and Postharvest Performance

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Consumer performance is critical to the success of greenhouse businesses. In recent years, greenhouse growers have reduced the amount of fertilizer applied to their spring bedding plant crops. This has resulted in concern about the performance of these plants once the consumer has purchased them. An experiment was designed to determine the effect of fertilizer concentration and plant growth regulator during the production phase on the growth of petunias (Petunia hybrida) in the consumer environment. Petunia ‘Pretty Grand Red’ plugs were transplanted into 6-pack containers (527 mL volume), grown at four concentrations of constant liquid fertilization (50, 100, 150 or 200 ppm N), and treated with four concentrations of paclobutrazol (0, 1, 2, or 3 ppm) in a 4 × 4 factorial arrangement. At flowering, the plants were placed into a simulated shipping and retail environment for 10 days. Then, the plants were transplanted into 1-L containers and grown for five weeks to observe consumer performance. No fertilizer was supplied in the post-production phases. Growth and flowering measurements were made following the consumer phase. Plant height increased linearly as the fertilizer concentration increased. Plant height increased by 34% as the fertilizer concentration increased from 50 to 200 ppm N. All three paclobutrazol treatments reduced plant height by ~15% compared to the untreated control. The number of flowers was highest in 150 and 200 ppm N treatments and there was 62% increase in flower number as the fertilizer concentration increased from 50–200 ppm N. Paclobutrazol application resulted in an 11% decrease in flower number. Shoot fresh weight per unit of plant height was used to assess plant quality. Using this measure, the plants grown with 150 and 200 ppm N displayed the highest quality during the consumer phase. Plant growth regulator had no effect on the shoot fresh weight per unit of plant height. The results of this study suggest that fertilizer and plant growth regulation play an important part in petunia growth during and after greenhouse production. In conclusion, low fertility and paclobutrazol applications during the production phase negatively impacted growth and flowering in the consumer phase.

8:30 AM – 8:45 AM

The Effects of Dehydration Duration on Water Uptake and Postharvest Quality of Cut Lilies

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We investigated the effects of dehydration duration on water uptake and postharvest quality of cut lilies. Stems of ‘Nashville’, ‘Santander’, and ‘Sorbonne’ were subjected to 0, 8, 24, or 48 h dehydration (at 20 °C) then put into test tubes containing 2% sucrose and biocide. Water uptake in the first 24 h of rehydration was significantly higher in dehydrated stems compared to controls. In ‘Nashville’, water uptake in the first 24 h of rehydration was significantly higher than in dehydrated stems. We also found that the percent of lily stems that had green leaf color and survived the last week postharvest was significantly higher in dehydrated stems than in controls. We conclude that dehydration duration is a variable that can be manipulated to improve postharvest quality of cut lilies.
An In Vitro Study Identifies Possible Bacteria Candidates for Botrytis Cinerea Biocontrol

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The use of beneficial bacteria as a form of biological control in the greenhouse production of floriculture crops is a growing area of interest, but many questions still surround the potential use of bacteria to control plant pathogens. Interest in biological control is increasing because of a desire by both consumers and growers to reduce the use of chemical pesticides. This is particularly important for the control of Botrytis cinerea, which is a fungal plant pathogen that affects many crop species worldwide. This pathogen has become resistant to some fungicides, increasing the urgency to identify alternative control methods. In this study, a collection of 61 Pseudomonas bacteria were screened to identify bacteria that inhibited the growth of B. cinerea. The objective of this study was to develop an in vitro assay that can be used to screen large collections of bacteria and identify those with the potential to control botrytis in floriculture crops. Identifying potential beneficial bacteria from large collections using only greenhouse trials is a difficult task because of the number of plants and greenhouse space required to evaluate large numbers of bacteria treatments. A dual plating assay was developed in which a single Pseudomonas strain was plated on PDA media with the B. cinerea to directly quantify any effects that the bacteria had on the growth of the pathogen. The negative control plates contained botrytis and no bacteria, while cycloheximide was included on the positive control plates in place of the bacteria. When the fungal growth of the negative control plates reached a predetermined point, measurements were taken on all plates to quantify Botrytis growth, and determine the zone of inhibition between the bacteria and botrytis. The experiment was designed to provide an initial screen for potential bacteria candidates. Based on the reduction of botrytis growth and the zone of inhibition, approximately twenty of the 61 strains tested were selected as potential biological control agents to use in the reduction of B. cinerea in floriculture crops. This dual plating assay can be used in the future screening of large collections of bacteria, and the selected Botrytis-active pseudomonads will be used in future greenhouse validation trials.

Specified Source(s) of Funding: DC Kiplinger Floriculture Endowment and American Floral Endowment

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Botrytis cinerea causes the decaying of cut rose flowers in both production and postharvest environments leading to economic losses. Commercial growers typically address this problem with weekly preventative fungicide applications. However, Botrytis has the ability to quickly develop resistance to single-site. This study was performed to evaluate the fungicide resistance in a commercial cut rose crop over time. Six commercial shipments of Rose ‘Orange Crush’ were received from the same greenhouse harvested over a period on several months. Upon arrival, the roses were incubated for seven days in chambers maintained at 22 °C and 100% humidity. When sporulation occurred after the incubation time, Botrytis conidia were collected and placed on media containing discriminatory doses of fungicides to distinguish between resistant and sensitive isolates, then incubated at 22 °C in the darkness for 4 d. Resistance was determined based on an observational assessment of the mycelial growth in the media for each fungicide. A total of eleven fungicides (thiophanate-methyl, iprodione, cyprodinil, boscalid, fenhexamid, penthiopyrad, fluopyram, isofetamid, fludioxonil, pydiflumetofen and polyoxin-D) belonging to seven FRAC codes were tested. A high degree of resistance was determined across the shipments to thiophanete-methyl, iprodione, cyprodinil and boscalid. In the case of fenhexamid, penthiopyrad, fluopyram, isofetamid, and fludioxonil, there was considerable variation in the fungicide resistance profiles.
Oral Presentations

**Oral Presentations**

**S150**

An asterisk (*) following a name indicates the presenting author.

### Ptelea trifoliata

Conflicting reports of the floral fragrance of Ptelea trifoliata, a dioecious species led us to question whether aromatic profiles of staminate and pistillate flowers differ. While similar compounds are present in both floral types, concentrations are different in ways that appear to affect how people perceive the fragrance. Human-subject assessments of floral volatiles of *Ptelea* confirmed that pistillate flowers are considered to smell floral and citrusy, whereas staminate flowers were additional scents that are considered to smell floral, citrusy, spicy, and pungently vegetative scents. Chromatography, spectrometry, and human responses indicate that the floral fragrance of *Ptelea* combines citrusy, spicy, floral, and pungently vegetative scents.

**Specified Source(s) of Funding:** American Floral Endowment

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**Growth Chambers and Controlled Environments 4**

**Moderator:** Celina Gomez  
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**8:00 AM – 8:15 AM**

### Effects of Light Quality on High-wire Tomato Ion Uptake, Partitioning, and Fruit Quality

**Meng-Yang Lin**  
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**Hye-Ji Kim**  
Purdue University, West Lafayette, IN, USA

Light-emitting diodes (LEDs) becomes popular supplemental lighting (SL) in greenhouse because of energy saving without compensating crop productivity. Accumulation of phytochemicals can be also induced by LEDs with specific spectrum in many crop species. However, recent study shows that phytochemical properties of greenhouse tomatoes remain unchanged in response to red (R, 600–700 nm), blue (B, 400–500 nm), and far-red (FR, 700–750 nm) SL from LEDs since the dynamic light environment in greenhouse nullifies the effects of wavelengths of light. Besides secondary metabolites, mineral nutrients are essential components for human nutrition and contribute to the quality and flavor of tomatoes. Ion uptake, translocation, and assimilation are also highly dependent on photosynthesis and photomorphogenesis, and therefore, responses of tomatoes to B, the signal of sunlight, and FR, the signal of shading, could be dramatically different in terms of ion utilization. The objectives of this study were to determine how different light quality affects ion accumulation, partitioning, and fruit quality of high-wire greenhouse tomato. ‘Merlice’ scions grafted onto ‘Maxifort’ rootstocks were supplemented with different combinations of B, R, and FR LED lighting: B + R (39%B : 61%R), R + high FR (71%R : 29%FR), or R only (100%R). Plants were fertigated with a commercial complete fertilizer mix (4.5N–14P–34K; CropKinging, Lodi, OH) to maintain acceptable electrical conductivity and pH in the root zone, and irrigation duration and frequency were adjusted to provide a daily leaching fraction of 30%. The concentration of nitrate, nitrite, sulfate, phosphate, chloride, sodium, potassium, magnesium, and calcium in leaf, stem, root, and fruit were determined by ion chromatography. On a whole plant scale, B increased the accumulation of nitrate and calcium while FR reduced their accumulation. Particularly, B increased the partitioning of phosphate to stem while FR decreased it. B also increased the partitioning of calcium from stem to leaf; however, FR increased its partitioning from stem to fruit in association with higher dry mass allocation to fruit relative to stem. The concentrations of sulfate and sodium were increased by 300% and 27% by adding FR to R, suggesting that FR improves the quality and flavor of tomato. Our results suggest that FR light reverses the action of B light in the accumulation and partitioning of some ions and mineral composition of tomato can be manipulated by additional FR light.

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**An asterisk (*) following a name indicates the presenting author.**

S150
Preliminary Evaluation of Four Soilless Substrates and Supplemental Arbuscular Mycorrhizal Fungi for Greenhouse Strawberry Production

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Increasing demand for locally grown produce with high flavor quality has led to a significant increase in controlled environment strawberry production in recent years. Additionally, challenges in traditional open field production, including loss of methyl bromide and labor shortages, could lead to soilless systems dominating the future market. Soilless substrate mixes need to be optimized for plant productivity, plant health, and ultimately grower profit. This study investigates effects of four different substrate mixtures on ‘Albion’ strawberry plant vigor, fruit yield, and fruit quality. The four substrates tested were: 1) a commercial mix developed for strawberry production, consisting of peat moss, perlite, chunk coco coir; and beneficial microbes (arbuscular mycorrhizal fungi (AMF) and biofungicide bacteria); 2) another commercial strawberry substrate mix composed of peat moss, tree bark fiber, coco coir, and the same microbial supplement; 3) our standard lab substrate for strawberry containing perlite, coco coir, and peat moss; and 4) the same lab substrate with supplemental AMF. Forty-eight ‘Albion’ plants were grown in each of the four substrates from Sept. 2017 to Apr. 2018 in a 103 m² glass greenhouse at The Ohio State University (Columbus, OH). Vegetative growth, fruit yield, and fruit quality (Brix and titratable acidity) were evaluated throughout the production period. At the transplant stage (12 Sept to 20 Nov. 2017), strawberry plants grown in Substrate 2 had the highest root-to-shoot dry mass ratio (1.10 ± 0.36) followed by Substrate 1 (0.67 ± 0.14), Substrate 4 (0.62 ± 0.080), and Substrate 3 (0.54 ± 0.070) indicating that use of commercial strawberry substrate mixtures or the addition of beneficial microbes to our standard substrate mix led to greater root development in early growth stages. Early fruit yield per plant (recorded from 1 Dec. 2017 to 7 Feb. 2018) was significantly greater in Substrate 4 (187.3 ± 4.6 g) and Substrate 2 (183.3 ± 6.2 g) than in Substrate 3 (143.9 ± 11.6 g) (Tukey hsd, P = 0.05). However, no significant difference was observed between Substrate 1 (164.6 ± 10.1 g) and any of the other three substrates. Furthermore, the average fruit size during the same early production season was the greatest in Substrate 2 (20.9 ± 0.27 g) and there were no significant differences among the other three substrates (ranging between 17.2 ± 0.84 and 18.6 ± 0.27 g) (Tukey hsd, P = 0.05). These results show increased productivity in plants grown when beneficial microbes were added in specific substrate mixes, suggesting the importance of chemical, physical and biological properties of substrate used in soilless strawberry production.

Higher Daily Light Integrals with Adaptive LED Lighting Control Speed up Ornamental Seedling Growth

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Supplemental lighting in greenhouse industry is often needed from late fall through early spring and can account for up to 30% of the value of crops produced. Reduction of this energy cost can be beneficial for profitable greenhouse crop production. Our study focused on quantifying the effect of daily light integral (DLI) on seedling production of bedding plants. We used an adaptive light-emitting diode (LED) control system to precisely control supplemental lighting by taking advantage of the dimmability of LED grow lights. The power of the LEDs was adjusted to provide only enough supplemental photosynthetic photon flux density (PPFD) to reach the threshold PPFD underneath the light bars. The threshold PPFD was recalculated every two seconds to assure that the crop received a specific DLI by the end of the 14-hour supplemental lighting period. This high-precision lighting control system provides supplemental light when plants can use it most efficiently, i.e., when there is little sunlight available. Therefore, we hypothesized that our adaptive LED control system stimulates plant growth more than ordinary lighting systems. We compared three adaptive lighting control treatments to achieve DLIs of 8, 12, and 16 mol·m⁻²·d⁻¹ in 14 hours of supplemental lighting (10 am to midnight) to a treatment that supplied a PPFD of ~100 μmol·m⁻²·s⁻¹ of supplemental light during the same 14 hours (average DLI was 8.6 mol·m⁻²·d⁻¹), and a sunlight-only control treatment (average DLI was 5.4 mol·m⁻²·d⁻¹). We used impatiens (Impatiens walleriana) ‘Accent Premium Violet F1’ and vinca (Catharanthus roseus) ‘Jams ‘n Jellies Blackberry’ for the study. Seedlings were harvested 40 days after seeding. The number of leaves, shoot fresh and dry weight, root dry weight, and plant compactness (shoot dry weight/ plant height) of both species were greatest in the treatment receiving a DLI of 16 mol·m⁻²·d⁻¹, followed by the treatment receiving a DLI of 12 mol·m⁻²·d⁻¹. Seedlings in the treatment that received a supplemental PPFD of ~100 μmol·m⁻²·s⁻¹ had similar growth as those in the treatment with a DLI of 8 mol·m⁻²·d⁻¹. The sunlight-only control treatment had the slowest seedling growth. These results suggest that our adaptive LED control system is capable of controlling LED’s precisely while stimulating the plant growth more at higher DLIs. However, growers should determine whether the better...
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

8:45 AM – 9:00 AM

Propagation of Herbaceous Perennials Under Sole-source Light-emitting Diodes or Greenhouse Supplemental Lighting from High-pressure Sodium Lamps

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Herbaceous perennials are propagated in early spring to late fall when outdoor daily temperatures and photosynthetic daily light integrals (DLIs) vary greatly. Inconsistent environmental conditions pose a challenge for propagators to consistently callus, root, and yield compact herbaceous perennial rooted liners. Research objectives were to evaluate and compare the effects of indoor sole-source lighting (SSL) delivered from red (R) and blue (B) light-emitting diodes (LEDs) to greenhouse supplemental lighting (SL) provided by high-pressure sodium (HPS) lamps during herbaceous perennial propagation. Cuttings of perennial sage (Salvia nemorosa L. ‘Lyrical Blues’) and wand flower (Gaura lindheimeri) were propagated in a walk-in growth chamber under multilayer SSL provided by LEDs with red [R; (660 nm)]: blue [B; (460 nm)] light ratios (%) of 100:0 (R:B), 75:25 (R:B), 50:50 (R:B), or 0:100 (R:B) delivering 60 µmol·m⁻²·s⁻¹ for 16 hours (DLI of 3.4 mol·m⁻²·d⁻¹). In a glass-glazed greenhouse, cuttings were propagated under ambient light and SL provided by HPS lamps delivering 58 µmol·m⁻²·s⁻¹ for 16 hours (DLI of 3.3 mol·m⁻²·d⁻¹). Ten days after sticking wand flower cuttings, callus diameter, a measure of growth, increased regardless of lighting treatments. At 10 d, stem length of perennial sage and wand flower propagated under SSL R50:B50 LEDs were 21 and 30% shorter and accumulated 50 and 8% greater root biomass, respectively, compared to those under SL. Cuttings propagated under SSL R50:B50 LEDs were similar or greater quality than cuttings under SL and thus, indicates that perennial sage and wand flower cuttings can be successfully propagated under LEDs in a multilayer SSL propagation system.

Production of Lettuce Increases by Utilizing a Longer Photoperiod with Consistent Daily Light Integral in Greenhouse Environments

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Rachel Schuster
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In the study, we quantified the effect of photoperiod while maintaining equal DLI in two experiments. First in growth chambers we grew red-leaf lettuce, Lactuca sativa ‘Red Sails’ under five photoperiods. We found biomass increased linearly with longer photoperiods, with 24-h plants averaging 82% increase in dry biomass in comparison to the 12-h treatment plants. Second, in a greenhouse we grew red-leaf lettuce, Lactuca sativa ‘Skyphos’, and found biomass increased in the 21-h treatment by an average of 49% in comparison to the 12-h treatment. This report demonstrates that greater production of lettuce can be achieved through precise control of DLI and photoperiod in the greenhouse. The benefits of extending photoperiod while maintaining daily light integral (DLI) have been demonstrated in the past to increase profitable production. Many significant horticultural crops, like lettuce, require a specific DLI that should be obtained, but not surpassed. To achieve lighting goals, a control algorithm using supplemental lighting must adjust light intensity to achieve the optimum photoperiod, without exceeding DLI, based on the variable daily sunlight conditions. Previously, due to the lighting technology at the time, lighting control algorithms could not utilize dimmability to achieve photoperiod and DLI simultaneously, therefore allowing for the most electrically efficient use of lighting. However, with the introduction of LEDs into horticultural environments, significant gains in the ability to control artificial light through rapid and instantaneous dimmability is now possible. Findings from this project have directed current research using a control algorithm to integrate the information from an ambient sunlight sensor with supplemental LED lighting in the greenhouse to maintain photoperiod while achieving the consistent DLI to optimize crop production utilizing supplemental LED lighting in greenhouses.

9:15 AM – 9:30 AM

Quantifying Water Use Efficiency of Two Lettuce Cultivars Grown under Red and Blue LEDs

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Luis Jonathan Clavijo
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Blue light is known to affect leaf stomatal development and aperture and has been shown to play a role regulating plant-water relations. The objective of this study was to quantify the effects of blue light on growth and morphology, water-use efficiency (WUE), stomatal conductance (gₛ), SPAD index, and shoot nitrogen uptake by ‘Cherokee’ and ‘Waldmann’s Green’ lettuce (Lactuca sativa) grown under different red-to-blue-light ratios. Seven treatments were evaluated in the study: 100% red; 7% blue + 93% red; 26% blue + 74% red; 42% blue + 58%...
red; 66% blue + 34% red; 100% blue; and broad-band white light (containing 19% blue, control). All treatments provided an average daily light integral (DLI) of 17.5 mol·m⁻²·d⁻¹ (270 ± 5 µmol·m⁻²·s⁻¹ over an 18-h photoperiod). The experiment was replicated three times over time; each experimental replication was terminated 21 d after treatment initiation. Regardless of cultivar, no treatment differences were measured for leaf area and specific leaf area (SLA). In contrast, for every 10% increase in blue light, leaf number and shoot dry mass (DM) decreased by 0.02 leaves and 0.2 g, respectively. Water-use efficiency also decreased linearly in response to blue light. Conversely, gs and SPAD index increased by 0.05 mmol·m⁻²·s⁻¹ and 0.02 units, respectively, for every 10% increase in blue light. Although tissue nitrogen content (mg·g⁻¹) increased with higher blue light, nitrogen uptake (mg) was unaffected by light quality. Our findings indicate that the significant decrease in WUE under higher blue light could be attributed to a reduction in plant growth (leaf number and DM) and an increase in gs, which may be the result of higher stomatal aperture and leaf conductance, and could lead to higher water loss through transpiration.

9:30 AM – 9:45 AM

Understanding Bases for Differences in Energy-use Efficiency among LED Grow Lights Using Hydroponic Lettuce

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Photosynthetic photon efficiency [PPE, mol. of light output per KWh of energy used; mol·(KWh)⁻¹] is one of the important characteristics used in marketing grow light fixtures for indoor production (vertical farms or plant factories). However, a more useful efficiency measurement for growers is energy-use efficiency [EUE, grams of dry weight produced per KWh of energy used, (g/KWh)], which is a product of PPE and light use efficiency [LUE, grams of dry weight produced per mol. of incident light, (g·mol⁻¹)]. While PPE is driven by engineering technology, LUE is influenced by physiological responses of plants to incident light intensity and composition. Information on PPE of a fixture is generally available from lighting companies, whereas LUE is species specific and limited information exist on LUE of a species under a specific fixture. This is the major reason why PPE is generally used for comparing light fixtures. Using hydroponically grown leaf lettuce, we studied differences in EUE, PPE and LUE among four commercially available light fixtures (Philips-Greenpower, Fluence-RazzX, TotalGrow-TG1A Bulb, and Lithonia-T8) which differed in the intensity and composition of incident light. Our results indicated that significant differences existed among light fixtures in EUE, PPE and LUE. More interestingly, when data from all fixtures were pooled in regression analysis, there was no relation between EUE and PPE among fixtures; whereas a strong linear relationship was found between EUE and LUE in hydroponically grown leaf lettuce. Further analysis indicated that LUE was linearly related to leaf growth rate (light interception), which decreased exponentially with increasing fraction of blue light (light composition) in the incident light. Leaf growth rate generally increased with increasing fraction of red light in the incident light. Fraction of red light decreased with increasing fraction of green light among fixtures. While acknowledging that observed responses are likely specific to leaf lettuce, we conclude that plant physiological responses to light (or LUE), can be an important characteristic in determining optimal lighting fixture for commercial indoor production.

Specified Source(s) of Funding: Purdue University

Fruit Tree Architecture and Orchard Mechanization

Coordinator /Moderator: Chunxian Chen
USDA, ARS, SEFTNRL, Byron, GA, USA

8:00 AM – 8:20 AM

Orchard Mechanization and Tree Architecture in Pome Fruit

Stefano Musacchi*
Washington State University, Wenatchee, WA, USA

Europe is one of the most progressive areas where mechanization is applied. Orchard mechanization requires an adjustment of the tree architecture and the development of training systems that allow the use of equipment. Initially, innovation was influenced by increased production costs and the breeding of new varieties. In fact, increasing labor costs and difficulties to find qualified workers represent the main drivers to mechanize in the orchard worldwide. Higher density plantings, with the goal of developing a small spindle canopy or a fruiting wall, have become widespread worldwide to increase labor efficiency. These orchards are characterized by early bearing and short life span. The sustainability and the possibility to mechanize these specialized orchards are some of the major topics of research. Many investigators are interested in how to make the orchard more efficient and reduce the amount of sprays necessary for maintenance through the development of more efficient training systems and new cultivars resistant to disease. Training systems for apple and pear are chosen in relation to the cultivar and rootstock vigor, and the ability to deliver fruit with a high percentage of blush or over-color, especially for bi-colored cultivars. Several kinds of equipment have been developed to mechanize the full cycle of the orchards from planting to harvest.

8:20 AM – 8:40 AM

Biology + Technology = Sustainable Orchard Systems

Matthew Whiting*
Washington State University, Prosser, WA, USA

An asterisk (*) following a name indicates the presenting author.
Oral Presentations

8:40 AM – 9:00 AM

**Fruit Tree Architecture Genomics and Breeding for Mechanization**

Kenong Xu*
Cornell University, Geneva, NY, USA

In commercial apple production, fruit harvesting and tree pruning are the two major contributors to the overall labor cost, which usually accounts for 60% of the total variable costs. The apple industry has long been seeking a viable means to mechanize such labor-intensive tasks in orchard operation. Several labor-saving platforms have been made available, and robotic prototypes for fully automated apple fruit harvesting have also been developed and tested recently. Although important progress has been achieved, it remains a long shot to adapt any of the robotic harvesting systems in orchard at a large scale. One of the major challenges has been the unpredictable fruit setting sites due to the complex canopy of apple trees. Attempting to provide genomic solutions that can simplify apple tree canopy and make the fruit setting locations predictable, we have been carrying out a research project to identify the genes and/or gene-networks responsible for varying tree architectural forms. Currently, we are focusing on the two extreme apple tree architectural forms, columnar and weeping, which are characterized by few upright and numerous downward branches, respectively. The latest results will be presented and discussed in the context of making apple trees friendlier for mechanized orchard management.

Specified Source(s) of Funding: NSF-Plant Genome Research Program grant IOS-1339211

9:00 AM – 9:20 AM

**Breeding Tree Architectures for Improve Orchard Productivity**

Jessica M. Guzman
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Chris Dardick*
Appalachian Fruit Research Station, USDA-ARS, Kearneysville, WV, USA

Tree management is the single most important factor that influences orchard productivity, starting with time of tree establishment and rootstock grafting followed by the continual pruning and training of the tree throughout its life. A broad range of management systems and strategies have been designed to maximize time to harvest, yield, and fruit quality while minimizing labor costs and chemical inputs. Currently, there is a sizeable knowledge gap in our understanding of the underlying growth and development mechanisms of trees which limits our ability to devise new solutions and/or genetically improve tree architectures. In particular, the growth patterns of branches including their growth dynamics and orientations as well as their interactions through apical dominance and apical control are poorly understood. Here we used gene expression profiling to compare shoot tips of apical and subtending first order lateral branches of young peach trees having different growth habits (standard, pillar, or weeping). Apical shoots in trees having a standard or pillar architecture displayed a cellular program that was clearly distinct from laterals, marked predominantly by down-regulation of a large set of genes. In contrast, very few significant differences were found when comparing lateral branches at different positions in the canopy or among shoot tips of weeping trees. Collectively, the data has important implications for understanding branch growth behavior and establishes a novel genetic program that is uniquely associated with apical shoots. Practical aspects of the work potentially related to management practices and/or breeding will be discussed.

9:20 AM – 9:40 AM

**Advances in Mechanized Tree Fruit Harvesting**

Changki Mo*
Washington State University Tri-Cities, Richland, WA, USA

Fresh market tree fruit harvesting is a difficult task that relies entirely on manual labor, but there exists a clear need for the technology in today’s economy. Extensive research has been done on the development of mechanical harvesting techniques. Several selective harvesting robots have been developed for research studies, but there are no commercially available robotic systems. This talk summarizes recent advances in mechanical tree fruit harvesting technologies. Because the fresh market apple industry is an agricultural sector with significant potential for the incorporation of robotic harvesting technologies, factors and considerations that are particularly applicable to apple picking are highlighted. In addition, it presents two studies of the design and field evaluation of robotic apple harvesters that have been conducted recently. In order to assess required functionality in modern orchard systems with ideal fruit distributions, an undersensed, low-cost system was developed. Based on local growers’ willingness to modify the tree to optimize fruit distribution for robotic harvesting, apples adjacent to trellis wires and trunks were removed prior to field studies. The robotic system
integrated a global camera set-up, seven DOF manipulator, and grasping end-effector of 3D printed tendon driven fingers to execute fruit picking with open-loop control. The design and development of a novel 3D printed soft robotic end-effector to facilitate apple separation was also presented. In this study, the field test was conducted in an unmodified field environment. Additionally, a secondary robot was implemented to catch the harvested fruit to facilitate fruit collection as an approach to potentially reduce the overall cycle time of robotic tree fruit harvesting. The soft robotic end-effector performed very well in grasping apples and facilitating apple separation. The compliant actuators were unharmed in collisions with the tree canopy and trellis wires offering a significant improvement in grasping speed over the tendon driven fingers. Results from field studies show that horticultural practices play a critical role in the selection of functionality requirements. Improved harvesting efficiency will require enhanced robustness, especially obstacle detection with increased visual sensing and force sensing on the end-effector for feedback on grasp status.

9:40 AM – 10:00 AM

Tree Fruit Orchard of the Future: An Overview
Chunxian Chen*
USDA-ARS, SEFTNRL, Byron, GA, USA

Mechanization has been prevailing in row crops over the past decades, and now gradually in some fruit crops, with integration of innovative computers, robotics, mechanics, and precision orchard management. This talk will give an overview of challenges facing commercial fruit industries and needs of new orchard systems for mechanization. Many fruit industries in recent years are encountering some tough headwinds: uncertainty and cost of labors, rampancy of destructive diseases, frequent occurrence of unfavorable weathers, competition of imports and other fruit commodities, marginalized profits, etc. These challenges impose a great impact on farming from multiple facets. The trend of changes includes much larger orchards, higher planting densities, simpler plant architecture, more precise management, and more mechanization. In other words, fruit tree crops are toward being planted, managed, and mechanized, to some extent, like row crops. In this context, horticulturists, engineers, and breeders are striving to sustain fruit industries and ensure orchard operation with up-to-date horticultural knowledge, optimized management, innovative automation, and desired cultivars and rootstocks.

Minimizing Food Safety Risks While Maintaining Quality of Fresh and Fresh-Cut Produce

*Coordinators:
Yaguang Luo
USDA-ARS, Beltsville, MD, USA
Jeffrey Brecht
University of Florida, Gainesville, FL, USA

8:00 AM – 8:15 AM

Fresh and Fresh-cut Produce Food Safety—Meeting Technical Challenges with Advances
Patricia D. Millner*
USDA-ARS, Beltsville, MD, USA

Fresh and fresh-cut horticultural food protection researchers along with supply chain partners have been actively engaged in a wide variety of technical studies and practices to improve food safety in the lead up to and since the enactment and implementation of the FDA Produce Safety Rule. This presentation will highlight key technical food safety challenges, data and technology gaps from farm to fork and feature how several major collaborative efforts, accomplishments, and lessons learned are continuing to advance technological improvements to meet the need for high quality and food safety of fresh produce.

8:15 AM – 8:30 AM

Knows, Unknowns, and Unknown Unknowns Regarding the Potential Microbial Risks for Ready-to-eat Produce
Eric C. Wilhelmsen*
Alliance of Technical Professionals, Milpitas, CA, USA

A modeling approach to using the knowledge (Knows) gained from industry bacterial testing programs to bound and limit the unknowns and unknown unknowns regarding microbial risk. The overall incidence rates for positive results in these databases are very low (1 in 5000 to 10000 tests depending on the product, season and other factors) limiting the utility of individual tests. However, large testing databases can be mined to yield information regarding the overall system under study and also yield information about what would not be consistent with the data and therefore, is not of concern. This mining approach can be bolstered by targeted intensive testing to yield additional information. Having this “is” and “is not” information about the system affords an approach to assessing and developing practical mitigation strategies in an environment where pasteurization is probably out of reach. This type of analysis should enable processors and their customers to make thoughtful decisions about their risk mitigation programs.

8:30 AM – 8:45 AM

Opening Pandora’s Box of Sprouts
Andrea Ottesen*
CFSAN FDA, College Park, MD, USA

In the past 20 years, the Food and Drug Administration has been involved in over 48 outbreaks associated with sprouts. These events resulted in 179 hospitalizations and 3 deaths. Most outbreaks were attributed to alfalfa sprouts, although clove, mung bean and sprouted chia were also implicated. Salmonella was the most common pathogen identified, followed by E. coli and then Listeria monocytogenes. There has been substantial interest from commercial sprout growers to apply metagenomic methods to
Prevention of Salmonella Contamination on Tomatoes during Simulated Dump-tank Washing

Xiangwu Nou*
USDA-ARS, Beltsville, MD, USA

Samantha Bolten
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Ganyu Gu
Virginia Tech, Painter, VA, USA

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Salmonella enterica is the primary foodborne bacterial pathogen of concern, and the target of antimicrobial intervention, for the tomato industry in the United States. The typical commercial tomato dump tank washing practice is a concern as a potential means by which contamination by S. enterica and other harmful microorganisms may be disseminated. Current government regulations and industry performance standards require the presence of sufficient amount of antimicrobial agents in the wash water to mitigate this food safety risk. Presently, maintaining a minimal 150 mg/L of free chlorine in a commercial tomato dump tank is required by the Florida state regulation in the US. While the industry is updating the food safety performance standards, scientific studies are needed to support the development and implementation of science- and risk-based food safety policies. We used grape tomatoes as a model to examine the contamination by Salmonella during a simulated process of tomato washing. Freshly harvested tomatoes were directly obtained from a major US tomato packing operation, and used for generating simulated wash water that matched several key parameters (Turbidity, TDS, and COD) of water used for washing cherry tomatoes by a commercial processor. Tomatoes and field debris were differentially inoculated by strains of different Salmonella serovars distinguishable by their resistance to different antibiotics. Non-inoculated tomatoes were concurrently washed with inoculated tomatoes and debris in the simulated wash water of varying free chlorine levels, with or with pre-washing or post-washing comingling. When inoculated tomatoes and field debris were washed together with non-inoculated tomatoes at free chlorine levels ranging from 5 to 150 mg/L, Salmonella populations on both inoculated tomatoes and field debris were reduced by approximately 2 logs, or approximately 1.2 log higher than that of washing without chlorination. Salmonella was not recovered from the spent wash water at any free chlorine level. Sporadic contamination of non-inoculated tomatoes was observed at lower levels of free chlorine. The contaminating salmonellae originated from both inoculated tomatoes and field debris. These observations indicate that field debris is an important source of cross contamination and removal of field debris prior to washing will reduce the bioburden and source of contamination.
are the main concerns for processors and marketers of postharvest fruits and vegetables. Like many water mediated sanitizers, ClO₂ solution has also been applied for a wide range of commodities. However, gaseous ClO₂ has many advantages over its aqueous formulations, including rapid diffusion, ease of mixing with air, and its ability to penetrate porous surfaces and biofilms. A controlled-release chlorine dioxide technology was used along with perforated packaging systems for grapefruit, cherry tomato, blueberry and strawberry fruits to mimic storage and transportation conditions. Gaseous CO₂ enhanced decontamination of both foodborne and plant pathogens. Significant microbial reduction was confirmed for inoculated foodborne pathogens, such as Escherichia coli, Salmonella, and plant disease pathogens, such as Alternaria alternata, Colletotrichum acutatum, penicillium digitatum, and naturally infected Xanthomonas citri ssp. citri and Lasiodiplodia theobromae in different fruits. In addition, gaseous ClO₂ also influenced some fruit physiological responses in that ClO₂-treated fruits exhibited less weight loss compared to controls, and also retained higher firmness.

9:15 AM – 9:30 AM

Food Quality and Safety Assessment of Packaged Leafy Greens after Storage in a Refrigerated Display Case with Doors

J. Atilio de Frias
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Xiangwu Nou
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Retail display of packaged fresh-cut leafy greens is a critical stage of the cold chain management and is prone to temperature abuse when produce is displayed in open cases, due to infiltration of ambient air into the case. Previous studies using a research supermarket demonstrated that produce quality is improved, energy costs were less and temperatures are more uniform when products are displayed behind doors. In this study, we evaluated changes in quality attributes and populations of inoculated bacterial pathogens in packaged baby spinach, chopped romaine, and lettuce mix displayed in a case retrofitted with doors. Compared to our previously published work with open display case, the case retrofitted with glass doors showed significantly improved temperature uniformity and control, thus avoiding temperature abuse and product freezing. All the products after 4-days display in the doored case maintained high freshness and attractiveness which were comparable to those stored at a constant temperature in a 1 °C cold room. Growth of inoculated E. coli O157:H7, Salmonella, and L. monocytogenes was minimal for all the displayed products. These results indicate that retrofitting display cases with doors is a practical means of reducing temperature abuse and product damage for fresh-cut display.

9:30 AM – 9:45 AM

Closed-door Refrigerated Retail Display Cases for Whole and Fresh-cut Produce: Are Temperature Management and Product Quality Improved?

Jeffrey Brecht*
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Ellen R. Bornhorst
ORISE, Beltsville, MD, USA

Keith Vorst
Iowa State University, Ames, IA, USA

Wyatt Brown
California Polytechnic State University, San Luis Obispo, CA, USA

We worked with a retailer in Florida to perform in-store measurements of temperature distributions in open and closed-door refrigerated display cases for whole and fresh-cut vegetables. Complementary projects were conducted with retailers in California, Iowa, and New York. The collaborating retailer selected two stores of the same size and identical floorplans, with comparable sales volumes and customer demographics. Refrigerated display cases in both stores were instrumented with eight temperature and humidity dataloggers per display case, placed in the front and back of the top, middle and bottom shelves. Doors were then retrofitted onto the display cases in one store and data were collected over 23 weeks from April to September 2017. Samples of bagged baby spinach were collected on a biweekly basis from the two stores and assessed for product quality and microbial growth. Temperature uniformity was improved in the closed-door display cases. Temperatures in the front were found to be 2.2 °C and 1.2 °C higher than in the back for open cases, but only 0.7 °C and 0.5 °C higher for closed cases in fresh-cut and whole vegetable displays, respectively. There was greater variation among temperatures at the back of the cases than the front, but that variation was reduced by half in the closed-door displays versus open displays. Use of doors decreased the temperatures inside the display cases by about 3.0 °C for fresh-cuts and 1.8 °C for whole vegetables, actually necessitating adjustment of temperature settings by +0.8 °C after retrofitting to avoid sub-zero temperatures. Saturated relative humidity was continuously recorded due to presence of free water from misting plus evaporation. Reduced energy consumption was also validated for display cases with doors. Assessments of product quality and microbial growth revealed no significant differences between baby spinach from open and closed-door
display cases, likely due to the relatively short residence time of the product on display (<12 hours).

9:45 AM – 10:00 AM

**Effect of Ginger Essential Oil on Citrus Fruit Pathogens and Fruit Decay When Applied in a Nano-emulsion Coating**

Elizabeth Baldwin*

USDA-ARS, Fort Pierce, FL, USA

Marcela Miranda

São Paulo State University, Araraquara, Brazil

Marcos David Ferreira

Embrapa Instrumentação- Brazilian Agricultural Research Corporation, São Carlos-SP, Brazil

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‘Nova’ mandarin were coated with commercial carnauba and shellac microemulsions and an experimental carnauba nanoemulsion coating compared to an uncoated control. Fruit quality evaluation included weight loss, gloss, soluble solids (SS), titratable acidity (TA), pH, SS/TA ratio, internal CO₂, O₂, and internal ethanol, and a sensory shine rank test after storage at 20 °C for 7 days. Conventional and nanoemulsion carnauba wax resulted in the least weight loss compared to control and shellac. There were no differences for gloss measurements, but gloss decreased with time and shellac-coated fruit ranked highest for shine in the sensory test. There were no differences for SS, TA, pH, and ratio among treatments, CO₂ and ethanol generally increased and O₂ decreased during storage while the highest levels of CO₂ and ethanol were found for the shellac treatment along with the lowest O₂, with no differences among the other treatments. Meanwhile, antimicrobial activity of ginger oil extracts (GOE) was evaluated using the poisoned food (PF) and inverted Petri-dishes test (IPD), minimum inhibitory concentration (MIC), minimum fungicide concentration (MFC) and percentage of spore germination for the citrus fruit pathogen, *Penicillium digitatum*. GOE significantly reduced mycelium growth of *P. digitatum* while spore germination was inhibited at 1% GOE, compared to 37.4% for controls after 24 h of incubation. GOE exhibited at a MIC between 0.4% and 0.8% (v/v). Now we will test the effect of 0.8% GOE in a nanoemulsion coating with *P. digitatum*-inoculated ‘Unique’ tangerines stored at 10 °C followed by a simulated marketing period for which results will be discussed.

Oral Presentations

**Water Utilization and Management 2**

*Moderator: Nastaran Basiri Jahromi*

University of Tennessee, Knoxville, TN, USA

8:00 AM – 8:15 AM

**Comparison of On-demand and Conventional Irrigation Regimes for ‘Silver Dollar’ Hydrangea Grown Outdoors in Biochar Amended Pine-bark**

Nastaran Basiri Jahromi*

University of Tennessee, Knoxville, TN, USA

Amy Fulcher

University of Tennessee, Knoxville, TN, USA

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University of Tennessee, Knoxville, TN, USA

James Altland

USDA-ARS, MWA ATRU, Wooster, OH, USA

Wesley Wright

University of Tennessee, Knoxville, USA

Controlling irrigation using timers, or manually operated systems are the most common irrigation scheduling methods in container production systems. Improving irrigation efficiency can be achieved by scheduling irrigation based on plant water needs and the appropriate use of sensors rather than relying on periodically adjusting irrigation volume based on perceived water needs. Substrate amendments such as biochar, a carbon-rich by-product of pyrolysis or gasification, can increase the amount of available water and improve irrigation efficiency and plant growth. Previous work examined two on-demand irrigation schedules in controlled environments. The objective of this research was to evaluate the impact of these on-demand irrigation schedules and hardwood biochar on water use and biomass gain of container-grown *Hydrangea paniculata* ‘Silver Dollar’ in a typical outdoor nursery production environment. Eighteen independently controlled irrigation zones were designed to test three irrigation schedules on ‘Silver Dollar’ hydrangea grown outdoors in pine bark amended with 0% or 25% hardwood biochar. The three irrigation schedules were conventional irrigation and two on-demand schedules, based on substrate physical properties and plant physiology. The conventional irrigation delivered 18 mm (0.7 inches) of water in one event each day. The substrate physical properties irrigation scheduling was based on the soilless substrate moisture characteristic curve. Irrigation was applied when the substrate water content decreased to the driest point at which there was plant available water, -10 kPa. The plant physiology irrigation schedule was based on a specific substrate moisture content derived from the relationship between substrate moisture content and photosynthetic rate. This system maintained volumetric water content (VWC) to support photosynthesis at 90% of the maximum predicted photosynthetic rate. Total water use was unaffected or lower in the on-demand irrigation systems. However, plant dry weight was 22% and 15% greater, water use efficiency was 36% and 40% greater, and total leachate volume was 25% and 30% lower in the substrate physical properties-based and plant physiology-based irrigation scheduling
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

Giulia Marino
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Crop coefficient (Kc) values commonly used in California for irrigating pistachio were developed in an earlier study (1985) conducted in a commercial, sprinkler-irrigated orchard of Kerman cultivar grafted onto *P. Atlantica* rootstock. Nowadays, the majority of pistachio in the San Joaquin Valley of California is grown with drip-irrigation, which could reduce the evaporative water losses and increase irrigation efficiency and water productivity. Our team of researchers from the University of California Cooperative Extension conducted a three-year field study (2015–17) to estimate the actual evapotranspiration (ETa) of a well-watered mature (30-year old, 75% canopy cover) commercial pistachio orchard (Kerman on PGI) grown on a sandy clay loam soil with drip irrigation in the San Joaquin Valley. We used the residual of energy balance method to estimate the actual water use, with a combination of eddy covariance and surface renewal equipment to measure the sensible heat flux density. The collected field data confirm the ability of pistachio trees to use large water volumes when irrigated for full production, with average ETa of 7.5 mm/day during the hottest months (June and July) and daily peak water use reaching up to 10 mm in late June. The highest Kc values reached 0.90 during the period from mid-May to mid-July. Kc was 0.80 from mid-April to mid-May and during August. In September, a steep decrease of Kc was observed, reaching values around 0.50, most likely as a result of preharvest reduced water applications by the grower. The Kc

8:15 AM – 8:30 AM

**Salt Risks Ultimately Become the Limit to Improved Irrigation Efficiency in Aridland Vegetable Cropping Systems**

Charles Sanchez*
University of Arizona, Yuma, AZ, USA

In aridland cropping systems salts are most effectively managed by leaching. When irrigation efficiencies are poor, the leaching requirements (LR) of salts for agricultural sustainability are often incidental to these inefficiencies. However, as irrigation efficiencies are improved, caution must be exercised so that the seasonal leaching fraction (LF) achieved is not less than the leaching required for continued sustainability. This presentation evaluates the multiple cropping systems in the lower Colorado River region. Water application efficiencies for the salt sensitive vegetable crops (fall-winter-spring) widely produced in the region have improved dramatically over the past two decades. In fact, many field irrigation operations in the vegetable cropping system, while providing for the crop’s water requirement, are net salt loading events (LF < LR). In contrast to the vegetable systems that are furrow irrigated, the spring-summer rotational field cropping systems are irrigated in basins, and due to slower irrigation advance resulting from increased soil and crop friction, net irrigation efficiencies are sometimes poor relative to crop consumptive use. Data we have collected suggests that these water application inefficiencies associated with the rotational crops, and associated leaching fractions, may sometimes be key to sustainability in the entire annual cropping system. Furthermore, preirrigation in the late summer before vegetables are planted is also important. Existing challenges to further improvements in irrigation efficiencies for the annual multi-cropping systems, in the context of salt management, will be discussed.

*Specified Source(s) of Funding*: Yume Center of Excellence in Desert Agriculture

8:30 AM – 8:45 AM

**Evapotranspiration and Crop Coefficients of Mature Pistachio Orchard Grown with Drip Irrigation in the San Joaquin Valley of California**

Daniele Zaccaria*
University of California, Davis, CA, USA

systems, respectively, compared to the conventional irrigation. This research demonstrated that on-demand irrigation scheduling with a physiological-basis or substrate physical-properties-basis could be an effective approach to increase water use efficiency for container-grown nursery crops without negatively affecting plant growth.

*Specified Source(s) of Funding*: This project was supported by Agriculture and Food Research Initiative Competitive Award No. #2015-68007-23212 from the USDA National Institute of Food and Agriculture.
Oral Presentations

values documented with the earlier study varied from 0.43 at the end of April to 1.19 in mid-July and decreased to 0.67 in October. The newly developed Kc trends should enable pistachio growers to achieve higher water productivity and improve the resource efficiency and pistachio production in the San Joaquin Valley.

Specified Source(s) of Funding: California Department of food and Agriculture (CDFA)

8:45 AM – 9:00 AM

Water Use of Drip-irrigated Pistachio Orchards Grown on Saline Soils in the San Joaquin Valley of California

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Pistachio acreage is rapidly expanding in California on salt-affected areas thanks to its economic profitability and salt tolerance. However, no information is currently available to growers on the actual water use of mature pistachio orchards grown on soils with high salinity. Our team of researchers from the University of California Cooperative Extension conducted a field study during the 2016 and 2017 crop seasons to determine the actual evapotranspiration (ETa) and crop coefficient (Ka) trends of one non-salt affected and two salt affected commercial pistachio orchards grown with drip irrigation in the San Joaquin Valley. We used the residual of energy balance method with a combination of eddy covariance and surface renewal to measure the sensible heat flux density. In addition, we collected the percentage of photosynthetically active radiation intercepted by the tree canopies (fPAR) and midday stem water potential (Ψstem) data to quantify tree canopy size and tree water status. The fPAR decreased from 75% for the non-salt affected orchard to 25% for the worst salt affected orchard, which had 10 to 30% lower seasonal ETa. The radiation interception was lower but the relative contribution of sensible heat flux to ETa increased to a maximum of 18% in the most salt impacted sites. The Ψstem values in the non-salt affected orchard were constantly above −1.5 MPa, whereas values Ψstem of around −3.0 MPa were reached in the salt affected orchards. The Kc of the salt affected orchards was 0.40 in April, between 0.60 and 0.80 from May to mid-July, and decreased to around 0.25 in October. Soil analysis highlighted that the conductivity (EC) did not explain the differences in ETa and fPAR among sites and suggested that the secondary effect of sodicity on soil physical properties (deflocculation, crusting, compaction, reduced infiltration, and aeration) may have a large effect on pistachio performance. Irrigation water volumes currently applied to salt affected orchards were as much as 33% higher than the measured seasonal ET values. This over application of “non beneficial” water not only decreases irrigation efficiency but also likely harms the trees as a result of reduced infiltration and water logging due to high sodicity and poor soil structure. Our results highlight the necessity to better understand the long term response of pistachio water use in salt affected soils to improve water management and orchard performance.

Specified Source(s) of Funding: California Department of food and Agriculture (CDFA)

9:00 AM – 9:15 AM

Assessing Soil Water Potential Thresholds for Optimum Irrigation Scheduling, Yield and Quality of Celery

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Jean Caron
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Scientific evidence of soil water potential impact on yield and quality of celery (Apium graveolens L.) production is very limited. A better understanding of the subject could set actionable targets for irrigation scheduling and the use of soil water potential sensors. Celery yield and quality, water use, soil mineral nitrogen (N), plant total N, soil electrical conductivity, root depth and canopy cover were assessed under four irrigation treatments...

An asterisk (*) following a name indicates the presenting author.
initiated at four different soil water potential targets in Oxnard, CA, during Spring 2017. The soil water potential was monitored at 8 and 18 inch depths using Horticau®’s TX4 Field Monitoring Stations. The four treatments consisted of initiating irrigation when soil water potential readings at the 8-inch depth reached –20, –30, –40, and –50 kPa, named T-20, T-30, T-40, and T-50, respectively. The amount of water applied at each irrigation was calculated based on the crop evapotranspiration since the last irrigation, with an additional leaching requirement of 30%. Treatments were replicated four times within a randomized complete-block design. Each plot consisted of three side-by-side 40 inches wide and 75 ft long beds, with two celery rows in each bed, and a drip tape on the top and center of the bed. Yield and quality data were collected in the center 20 ft of the middle bed of each plot. Total and marketable yield and plant height linearly decreased from T-20 to T-50 (P < 0.050). Total and marketable yield were 11.4% and 9.0% smaller, respectively, for T-50 compared to T-20. Whole plant weight and marketable plant weight also decreased from T-20 to T-50, with significant differences (P < 0.05) between T-20 and T-50. There were no trends nor significant differences (P = 0.596) of pith among treatments. Water use was very similar, totaling 19.7, 18.9, 18.6, and 18.4 inches for T-20, T-30, T-40 and T-50, respectively. Soil mineral N, plant total N, soil electrical conductivity, rooting depth and canopy cover at harvest were very similar and not significantly different (P > 0.05) among treatments. The averages of the highest soil water potential values at 8-inch depth prior to each irrigation were –25.9, –36.2, –43.7, and –52.0 kPa for T-20, T-30, T-40, and T-50, respectively. Overall, the results of this study suggest that initiating irrigation at soil water potential lower than –20 kPa decreases celery yield, plant height and plant weight in proportion with the decrease of soil water potential down to –50 kPa, but it didn’t affect pith.

Specified Source(s) of Funding: California Celery Advisory Research Board

9:15 AM – 9:30 AM

Applying Controlled-release Fertilizer in Green Beans: May or May Not Work
Qingren Wang*
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Application of controlled-release fertilizer (CRF) has shown great advantages in improving crop yield, reducing labor cost from farming operation, promoting fertilizer use efficiency, and protecting environment for a sustainable development in agriculture. However, a relatively higher price for CRF as compared to conventional fertilizer (CoF) is one of main obstacles for growers. In addition, a feasibility of the right source of fertilizers also depends on right crops associated with good management practices, especially with water management. To compare these two different fertilizers in vegetable crops, field demonstration trials were conducted on the Experimental Farm at the University of Florida/IFAS Tropical Research and Education Center in different years with various water supplies in green beans. The results showed that the yield of green beans was increased significantly in one year but not in the other year. Water supply seems play a critical role to improve the release of plant available nutrients from CRF and help increase the crop yield. A short life crop, such as green beans with only 56–58 days after sown, may not have enough time for the given CRF to function, especially when the water supply is limited. In conclusion, the application of CRF needs right type, right crop and with sufficient water supply to optimize the output.  

Specified Source(s) of Funding: Florida Department of Agricultural and Consumer Services

9:30 AM – 9:45 AM

Creation and Adoption of Smart Agriculture Innovations to Cope with Climatic Uncertainty
Clinton Shock*
Oregon State University, Ontario, OR, USA

Human needs for nutrition and income in climatic uncertainty provide strong incentives for us to seek solutions to agriculture and community problems. The creation and adoption of innovative changes can result in the smart use of water, soil, and nutrients. Irrigation innovations are continually being created by scientists, agricultural industries, and growers. Irrigation efficiency is increased through more efficient systems and components, closer matching of irrigation to crop species needs, and better knowledge of each crop’s physiology to understand the amounts of water stress tolerated in various phases of crop development. New options are creatively imagined to provide feasible solutions compatible with local production methods. These options must be winnowed with realistic field tests pertinent to local constraints. Examples of changes in irrigation systems, irrigation scheduling, crop physiology applications, and more efficient nutrient management will be presented.

Specified Source(s) of Funding: Oregon State University

9:45 AM – 10:00 AM

Substrate Moisture Effects on Growth, Yield and Quality of Strawberry (Fragaria ×ananassa)
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John Lea-Cox
University of Maryland, College Park, MD, USA

We are investigating the effect of sustained substrate moisture levels on the growth, yield and fruit quality of the strawberry (Fragaria ×ananassa) cv. ‘Chandler’ and ‘Sweet Charlie’. The experiment was setup in a randomized complete block design with four replications in the Research Greenhouse at the University of Maryland, College Park. Plugs of the cultivars were transplanted to 3.8-L pots filled with a commercial substrate (Sunshine LC1 Mix, Sungro Horticulture, Agawam, MA) composed of 75 to 85% peat moss and 15 to 25% perlite on volume basis. The moisture release curve for the substrate mix was developed using Hyprop
device (METER Group Inc., Pullman, WA) in order to correlate volumetric water contents with corresponding matric potential and four soil volumetric content levels were selected as treatment set-points. These VWC set-points were 40%, 30%, 20%, and 15% and represented 67.7%, 50%, 33.3%, and 25% of container capacity for the substrate mix, respectively. Corresponding matric potential values for the VWC set-points were -4.3, -13.8, -36.7 and -63 kPa. GS-1 Soil moisture sensors (METER Group Inc.) were inserted in three plants per experimental unit and readings were recorded on a 5-minute basis using Em50R data loggers (METER Group Inc.). Data was transmitted to Sensorweb™ software (Mayim LLC., Pittsburgh, PA) and averaged on a 15-minute basis. Irrigation happened whenever averaged values were less than corresponding set-point for each treatment. In addition to VWC, substrate matric potential (MPS-6), electrical conductivity and temperature (GS-3), and irrigation volumes (Model 25, Badger Meter, Milwaukee, WI) were also recorded on a 5-min basis using the Em50R data loggers. For four weeks after transplant, all treatments were irrigated fully to allow establishment. Destructive harvest was done at the end of December in order to quantify growth effects. There were significant differences in branch crown number, leaf area, leaf fresh mass, stem fresh mass, leaf dry mass, stem dry mass and root dry mass for ‘Sweet Charlie’. None of these parameters were significantly different for Chandler. While both cultivars are short day (June bearing), Sweet Charlie is an earlier cultivar compared to Chandler and is likely to have more rapid growth compared to Chandler. Additional destructive harvest will be done at the end of vegetative growth in the spring and after fruits harvest. Our understanding of how plant growth, yield and quality respond to varying soil moisture regimes is important to devise efficient irrigation practices for strawberry production in various soils as well as soilless substrates.

Organic Horticulture 2
Moderator: Kathleen Delate
Iowa State University, Ames, IA, USA

8:15 AM – 8:30 AM

Robotic Weeds in Organic Vegetable Cropping Systems
Kathleen Delate*
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Robert Turnbull
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Lie Tang
Iowa State University, Ames, IA, USA
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Improved methods for weed management are considered some of the most pressing needs in organic crop production. Robotic weeding offers a possibility of controlling weeds precisely, particularly for weeds growing near or within crop rows. A study was conducted in 2016 and 2017 at an Iowa State University research farm near Gilbert, Iowa, to examine a machine vision system, based on a Kinect™ V2 sensor, to recognize and localize crop plants at different growth stages, through the fusion of two-dimensional textural data and three-dimensional spatial data, as the first step in constructing an autonomous weeder. Lettuce and broccoli were transplanted at a distance of 61 cm between plants and 91 cm between rows. Weeds at the site consisted of lambquarters (Chenopodium album), bromegrass (Bromus inermis), pigweed (Amaranthus spp.), waterhemp (Amaranthus rudis), cockspur grass (Echinochloa crus-galli), bindweed (Convolvulus arvensis), purslane (Portulaca oleracea), and white clover (Trifolium repens). Weed populations were not adjusted until after sensor measurements were made. Several feature extraction algorithms were developed for broccoli and lettuce which were heavily infested by the aforementioned weed species. Crop plant recognition algorithms were developed to address the problems of canopy occlusion and leaf damage. With our proposed algorithms, different features in the 3D point cloud data of plants were extracted and used to train plant and background classifiers. For broccoli, the detection rate was 93.1%, and the average localization error was 10.1 mm. For lettuce, the detection rate was 93.7%, and the average localization error was 8.3 mm. The results have shown that 3D-imaging-based plant recognition algorithms are effective and reliable for crop/weed differentiation, which forms the basis for the next steps in developing a fully functioning robotic weeder.

Specified Source(s) of Funding: NIFA AFRI

8:30 AM – 8:45 AM

Acetic Acid (Vinegar)—An Economical and Effective Diluent for Organic Herbicides
Ramdas Kanissery*
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Horticulture producers, as well as home gardeners, constantly ask about an economic at the same time effective substitute to expensive herbicides that can be used in organic production systems. A specific interest is in a cost-effective alternative to the herbicidal product, such as Axxe, an OMRI listed broad-spectrum herbicide that controls grasses and broadleaf weeds. The key ingredient in this herbicidal soap is a form of ammoniated pelargonic salts. They work by burning plant foliage that is contacted by the product. Lately, a great deal of interest has been conveyed in the use of acetic acid, commonly known as vinegar, as a broad-spectrum herbicide. While many subjective reports of the effectiveness of vinegar have been available, research to substantiate these claims is inadequate. The current study evaluated the herbicidal effectiveness of acetic acid when used as a diluent for the herbicide product Axxe, for row-middle weed management in organic plasticulture systems. The experiment was conducted in an herb (Rosemary), under organic production. When the standard use rate of herbicide...
Axxe was diluted to half rate with vinegar (5% acetic acid), the control of broad-leaved weeds and grasses was equivalent to the full use rate of Axxe. This study showed that acetic acid could be a viable and cost-effective diluent for herbicides like Axxe, from an economic perspective of broad-spectrum weed control in organic production.

8:45 AM – 9:00 AM

Covering Ground: A Systems Evaluation of Between-row Management Strategies in Organic Plasticulture Vegetable Production

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The use of plastic mulch (PM) is common for warm-season organic vegetable production in Michigan. While PM offers excellent weed control in-row, weed management between-row remains a challenge. Organic growers employ a variety of strategies to manage this area including cultivation, mowing, straw mulching, and less commonly, planting cover crops as living mulches. While these practices impact crop production and soil quality differently, information regarding the potential benefits and tradeoffs of each management strategy is lacking. The objective of this study is to clarify how between-row management affects both crop production and soil health indicators, allowing growers to make informed management decisions considering their unique farm context and goals. Strategies (treatments) evaluated in this study included weed-free wheel-hoe cultivation, rye cut and carry (dead) mulch, mowing weeds, rye living mulch, rye/white clover living mulch, and Italian ryegrass living mulch. These strategies were implemented between bell pepper (Capsicum annuum cv. Paladin) and summer squash (Cucurbita pepo cv. Lioness) grown on PM to allow for comparisons between a relatively short- and long-duration crop. First year (2017) results demonstrate that competitive inhibition by living mulch and weeds is cash crop dependent. Summer squash yields were consistent across management strategies, but total pepper yields were reduced by an average of 453 g per plant (~30%) in all treatments compared to weed-free cultivation. Cumulative biomass production in the between-row area was not significantly different between mowed weeds and living mulch treatments, averaging 490 g m⁻² biomass accumulated over the course of the growing season. Dead mulch reduced in-season weed biomass by 75% relative to the mowed weeds control, more than any living mulch species. Italian ryegrass was the only living mulch species to significantly decrease in-season weed biomass with a 52% reduction. Both mowed weeds and living mulch plots were able to scavenge between-row nitrogen, resulting in significantly less potentially leachable nitrogen in the fall (0–60 cm soil depth) compared to dead mulch and weed-free cultivated treatments. Significant differences in soil microbial biomass and shifts in soil microbial communities were not observed at any of four sampling dates during the first year of this study. However, this trial will be repeated in the same location in 2018 to evaluate cumulative impacts of between-row management on soil organic matter, microbial activity, and weed seedbanks.

Specified Source(s) of Funding: North Central SARE

9:00 AM – 9:15 AM

Tomato Varieties for Organic High Tunnel and Field Systems: Are Separate Breeding Programs Needed?

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While tomato is important to global markets, it is also the iconic local vegetable, and consumers seek out the flavor of locally produced tomatoes. In Northern climates, production over a longer season is important to direct-market farmers. Farmers who have the first tomatoes at market can gain customers and keep them over the year. For this reason, many growers are using high tunnels to extend their season. We compared a diverse set of varieties in high tunnel and field organic production environments. Our objectives were to determine if there was significant genotype by management system interaction for productivity, disease susceptibility and quality, in order to set breeding priorities for the two management systems. We also used data from the trials to compare different pricing scenarios for both early and late production for slicer and heirloom market classes. Labor hours were recorded to compare the cost of production for each system as well. Management system had the largest effect on yield and disease, with the high tunnel producing 8.7 kg/plant compared to 5.1 kg/plant in the field, overall varieties and years. The incidence and severity of disease in the field was much greater than in the high tunnel. The average area under the disease progress curve was over four times greater in the field than in the high tunnel. Quality traits were more influenced by variety, although management also had an effect. Large slicers had the lowest "Brix value and flavor intensity, while heirlooms and small slicers had higher "Brix and flavor intensity. Flavor intensity was strongly correlated to preference. While there was not significant genotype by management system interaction for yield or disease susceptibility, the traits required in each system were different enough to justify separate breeding projects. Breeding for early blight, septoria
and bacterial speck resistance, combined with excellent flavor, is the top priority for field production. For high tunnels, pushing production even earlier while maintaining flavor is a top grower priority, and reducing susceptibility to blossom end rot and green shouldering is critical. Some heirloom varieties would need to be priced considerably higher than slicers to have equivalent revenue, but we identified some very promising new varieties, selected to have the flavor of heirlooms with higher productivity. Labor hours were surprisingly similar between the two systems, confirming what growers have been demonstrating, that high tunnel tomato production can quickly pay off the structure and be highly profitable.

**Specified Source(s) of Funding:** North Central SARE

9:15 AM – 9:30 AM

**Production Potential of Organically Managed June-bearing Strawberry Varieties Grown under High Tunnels and Low Tunnels**

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The use of protected agriculture such as high tunnels and low tunnels have grown in popularity over the years, however not much research has been done on the actual potential of crop protection that can be offered from the use of low tunnels inside of high tunnels. This two-year study took place at the North Carolina Agriculture and Technical State University farm in Greensboro, NC (hardiness zone 7). The high tunnel was 30′ (W) × 96′ (L), managed organically and had a single layer 6mil polyplastic cover. Low tunnels consisted of metal wire hoops covered with 1mil perforated plastic. The experimental design was a completely randomized design (CRD), conducted as a splitplot with three replications. The main plots were black plastic mulched beds combined with or without low tunnels; the split plots were cultivars Benicia, Camino Real, Florida Radiance, and Winterstar. Strawberry plugs were planted on 1Sept. 2016 and 2017. Marketable yields were not affected by low tunnel treatments. However, there were significant differences between the four varieties. Marketable yields were not affected by treatments, between low tunnel and no low tunnel, however there were significant differences between the four varieties. From the 2016/17 season, marketable yield totals were 386.18 g/plant with low tunnels and 433.84 without low tunnels. ‘Florida Radiance’ (475.14 g/plant) had the highest marketable yield, followed by ‘Camino Real’ (428.06), ‘Benicia’ (381.22), and ‘Winterstar’ (355.6). From the 2017/18 season (up to February 28) the marketable yield was 39.1 g/plant with low tunnels and 32.7 without low tunnels. The marketable yields for cultivars are as follows: ‘Winterstar’ (47.9 g/plant) had the highest marketable yield, followed by ‘Florida Radiance’ (46.5), ‘Benicia’ (32.8), and ‘Camino Real’ (16.5). Overall, using low tunnels inside high tunnels may not be more effective than using high tunnels alone, but choosing more productive varieties may be a more beneficial option. This study will continue until May 2018 for complete evaluations of the low/high tunnel systems and cultivars.

9:30 AM – 9:45 AM

**Meta-analysis of Organic Research Results**

Diana Jerkins
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Michael Stein*
Organic Farming Research Foundation, Santa Cruz, CA, USA

There is a growing body of organic research that is available to researchers, extension, and farmers. Learn about current research topics and results that is adoptable for farmers and ranchers and furthering next generation of research. In this session, highlighted results on production practices, breeding, and economic trends from USDA-funded and Organic Farming Research Foundation (OFRF)–funded research from the past decade will be presented. Special focus will be on soil health and organic production. Participants will learn who funds major organic research and where funds have been spent. An interactive discussion will be done to gather input about future organic research needs.

9:45 AM – 10:00 AM

**Screening of Serviceberry Cultivars for Phenolic Antioxidant-linked Anti-diabetic Properties Using Rapid In Vitro Assay Models**

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Kalidas Shetty
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Serviceberry (Amelanchier spp.), a native temperate berry from North America, is a rich source of cold and other abiotic stress...
adaptation relevant protective bioactives such as phenolic metabolites. These same abiotic stress-related phenolic bioactives of serviceberry also have human health relevant protective functions and can be targeted for dietary and therapeutic support against diet and oxidative stress-linked chronic diseases such as early stages of type 2 diabetes and associated health risks. However, human health relevant phenolic bioactive profiles and associated health benefits of serviceberry vary between cultivars, environment, maturity and postharvest storage conditions. Based on this biochemical and physiological rationale, the objective of this study was to screen and determine phenolic bioactive-linked antioxidant and anti-hyperglycemic properties of 20 serviceberry cultivars targeting dietary and therapeutic support against early stages of type 2 diabetes using rapid in vitro assay models. Cold water extracts (food grade) of 20 serviceberry cultivars from North America were evaluated for total soluble phenolic (TSP) content, phenolic acid profiles, total antioxidant activity (DPPH and ABTS radical scavenging activity), α-amylase, α-glucosidase, and angiotensin-I-converting enzyme (ACE) inhibitory activities using in vitro assay models. Significant differences in TSP content, antioxidant activity, and in vitro glucose metabolism relevant (α-amylase, and α-glucosidase) enzyme inhibitory activities were observed among serviceberry cultivars. High TSP content (2.8-3.2 mg/g FW) was observed in 12-1, 41-1, Parkhill, Smoky, and Buffalo cultivars, while high DPPH and ABTS radical scavenging assay based antioxidant activity (80 to 100% inhibition) was observed in 14-2, Thiesen, 1-4, 1-2, and 18-1 cultivars. Furthermore, very high in vitro α-amylase and α-glucosidase enzyme inhibitory activities (> 90%) and significant dose responses were also observed in all serviceberry cultivars. The result of this study provides biochemical rationale to select and target high phenolic and high antioxidant serviceberry cultivars for further animal model based in vivo and clinical studies targeting dietary and therapeutic applications against early stages type 2 diabetes and associated macro and micro-vascular complications.

Specified Source(s) of Funding: North Dakota Specialty Block Grant funded part of the research associated with this abstract

10:00 AM – 10:15 AM

Food Pathogen Attachment on Different Level of Epicuticular Wax Surface of Vegetables

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Although understanding attachment mechanism of Salmonella to produce surface is crucial information for reducing food pathogen outbreak, the bacterial attachment to different surface properties of leaves is not fully understood. Epicuticular wax is the most outer layer on the leaf surface that directly interact with food pathogen attachment. The hydrophobic nature of epicuticular wax has been found to have positive attributes to pathogen resistance due to the prevention of spore germination, however, there is limited study on if the amount of epicuticular wax layer on the leaf is correlated with the attachment ability of Salmonella. The goal of this study is to examine attachment strength of Salmonella on various leafy vegetable surface including collard green cultivars (‘Green glaze’ as glossy leaf type and ‘Top Bunch’ as waxy leaf type (Brassica oleracea L. Acephala group), two sets of broccoli isogenic (USDA115 glossy and waxy; USDA188 glossy and waxy), and flowering lettuce. The leaf surface image of all vegetables examined by scanning electron micrographs (SEM) showed the topographical difference; net-like waxy crystals were deposited on ‘Top Bunch’ and waxy broccoli (USDA188 and USDA115) leaf surface and the waxy layer made less visible stomata compared to glossy collard ‘Green Glaze’ and glossy broccoli (USDA188 and USDA115). Characteristic of crystalline wax structures on lettuce leaf epidermis was platelets with few needles. Total wax content of waxy collard was 94.85 ± 7.41 μg/cm² with total fatty acids concentration 24.1 μg/cm², total alkanes 776.6 μg/cm², total alcohol 96.1 μg/cm² and total ketone 394.3 μg/cm². By contrast, total wax content of glossy collard was 2.31±0.39 μg/cm² with total fatty acid concentration 22.6 24.1 μg/mL, total alkanes 2.8 μg/mL, total alcohol 6.1 μg/mL and non-detectable ketone concentration. The total amount of epicuticular wax on apical and middle attached leaves of flowering stem in lettuce had about six fold higher than lower leaves (31–39 μg/cm²). The attachment of Salmonella was significantly stronger on the glossy collard (10⁶ CFU/g) rather than the waxy collard (10⁴ CFU/g). The different Salmonella attachment was maintained during postharvest storage. We also confirm the same trend using broccoli isogenic lines and flowering lettuce model. To confirm the epicuticular wax effect on Salmonella attachment, epicuticular waxes were removed by arabic gum treatment and test the Salmonella attachment. Salmonella attachment was significantly increased after epicuticular wax removal. These results suggest the presence of epicuticular wax has negatively influence on Salmonella attachment and the cultivar chosen for the salad leaves can potentially be considered to reduce the risk of foodborne contamination during preharvest and postharvest condition.

10:15 AM – 10:30 AM

Effect of Boiling, Steaming, and Microwaving on Glucosinolate and Primary Metabolite Profile in Methyl Jasmonate Treated Broccoli

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Many research have shown glucosinolate (GS) loss during cooking process in broccoli. While methyl jasmonate (MeJA)
application significantly increases health-promoting GS in broccoli (Brassica oleracea var. Italica) by mimicking insect damage, limited research looked at how MeJA application affects GS retention after cooking. To fully utilize MeJA application, we aimed to measure how MeJA application affects GS retention after cooking. In this study, 250 µM MeJA was applied to ‘Green Magic’ broccoli four days before the harvest and we measured GS in broccoli, GS in cooking water, electrical conductance, and primary metabolites to evaluate the phytochemical profile change after three different cooking methods (boiling, steaming, and microwaving) and two cooking times (2 and 5 minutes) on control and MeJA-treated broccoli. In raw broccoli, MeJA treatment significantly ($P<0.05$) induced progoitrin (19%) and glucoraphanin (43%), glucobrassicin (52%), neoglucobrassicin (488%), and 4-methoxy-glucobrassicin (21%) compare to the control. Among six cooking treatments (methods × times), 5 minutes boiling led to the most significant loss in total indole (22%) and indole GS loss (62%) in control while it caused 47% total aliphatic and 54% indole GS loss in MeJA-treated broccoli. Even though GS loss rate were high in both control and MeJA-treated broccoli, only 5 minutes boiling cooking water from control broccoli consistently contained highest amount of glucoraphanin (0.04 µmol/g DW), total aliphatic GS (0.06 µmol/g DW), neoglucobrassicin (0.18 µmol/g DW), and total indole GS (0.2 µmol/g DW) at $P < 0.05$; however, no significant difference was detected in MeJA-treated broccoli cooking water regardless of cooking treatments. In addition, the highest electrical conductance (EC) value was observed in control boiling 5 minutes cooking water and then MeJA 5 minutes boiling water, followed by steaming water and then microwaving water. This indicated the higher cell membrane leakage in the boiling treatment was observed in control and MeJA-treated broccoli. Sucrose, fructose, glucose, proline, isoleucine, valine, serine, oxoproline, and glutamic acid were significantly reduced in MeJA treated raw broccoli compared to control. In cooked broccoli serine was the most discriminating metabolites among all treatments, and only microwaving did not lose serine during cooking. In control cooked broccoli, sucrose was the most significantly different biomarker from partial least squares discriminant analysis while fructose was the most important biomarker in MeJA-treated broccoli. Our results suggested MeJA application on broccoli can potentially retain higher GS to provide improved phytochemicals in broccoli after cooking.

10:30 AM – 10:45 AM

**Mungbean: A Potential Health-food Sprouted Bean Crop in Alabama**

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Mungbean (**Vigna radiata**) is a short-season, drought tolerant crop that can be grown as a rain-fed crop on marginal soils in Alabama. Mungbean seed is rich in protein (24%), dietary fibers, vitamins A, C and B12 complex, but low in fats, sodium, and cholesterol. In the United States, mungbean is well known as bean sprouts used in salads and soups, and is gaining popularity as a health food for combating obesity and diabetes. Approximately 10 million kg of mungbean is consumed annually in the United States (U.S.), of which about 75% is imported from Asian countries because of limited production in the U.S. The objective of the study was to assess mungbean varieties for yield and sprouted bean nutritional quality for potential commercial production in Alabama. Five mungbean varieties, Chinese Organic (CH-O), Chinese Conventional (CH-2, CH-3), Indian (IN-1), and Tennessee, US (TN-1) were planted in single row plots and were assessed for growth, yield, and seed nutritional qualities. Seed yield was determined per plant by harvesting plants from one-m row length of each variety. Hundred g of mungbean seeds of each variety were sprouted. The dry seed and sprouted seed were analyzed for mineral content using the OEC ICP Spectrometer. The total phytic acid, total flavonoid content, crude protein, oil, and condensed tannins were determined using appropriate methods. The number of pods/plant and seed wt./plant ranged from 42 (CH-2&CH-3) to 79 (CH-O) and 26 (IN-1) and 78 (CH-O), respectively. Chinese Organic Mungbean (CH-O) with more and heavier pods per plant out-yielded other varieties by 56%. Sprouted beans of all varieties possessed lower levels of total phytic acid than dry seeds. Total flavonoid content of dry seed ranged from 0.109 (CH-2) to 0.235 ug/g (IN-1). The percentage oil and crude protein of sprouted beans ranged from 0.3 (CH-3) to 0.9 (TN-1) and from 21.8 (IN-1) to 23.2 (CH-2), respectively. There was a significant reduction in condensed tannin when the seeds were sprouted. Minerals K and Na were higher among sprouted beans. Fe level decreased in sprouted, while Mn and Ca were higher in sprouted than dry seed in IN-1, CH-2 and CH-3. The variation in seed yield and nutritional traits of the varieties indicates that mungbean offers potential for commercial production as a health-food crop in Alabama.

*Specified Source(s) of Funding: NIFA-ALDI-16SCBGPAL0004-12*
Establishment of an Apple Orchard: Year 1

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Historically, the tri-county (Wicomico, Somerset, and Worcester) area was known for fruit cultivation on the Eastern Shore of Maryland (MD). A USDA census of agriculture in 1925 showed 6.0 million pounds (m lb) of apple production in this area, which was dominated by Worcester (4.3 m lb) and followed by Wicomico (0.9 m lb) and Somerset (0.7 m lb) county. However, currently there is no commercial apple production in these counties (USDA, NASS 2012). We recently established an apple orchard at University of Maryland Eastern Shore (UMES) to rejuvenate the lost commercial apple industry on the Eastern Shore of MD. This medium density, multi-variety and multi-rootstock (5)/scion (30) apple orchard is the site for hand-on training for growers, beginner farmers, farm managers, stakeholders, and extension associates to generate human resources to popularize the apple cultivation on the Eastern Shore of Maryland and adjoining urban areas. This orchard will be commercially productive within the next 3–4 years, giving all interested parties multiple opportunities to see the progression of the apple orchard from planting through initial productivity and harvesting. Within a year after planting in Mar. 2017, four workshops were conducted on establishment of apple orchard, basics of pruning, rootstock/scion selection, and overview of the tall spindle system. This project got wide media coverage and larger number of local growers, small farmers, home owner, and schools became the part of this project. With the help of SARE funding, an apple team was recruited in the Tri-County area comprises of 25 stakeholders, growers, and extension agents for a period of three years. In addition, another apple team was recruited in Virginia through Virginia State University, Cooperative Extension following a workshop in Mar. 2018. Thirteen growers came forward and showed interest to conduct workshops frequently to enrich the knowledge of apple cultivation. Our orchard is visited by more than 200 visitors since Mar. 2017. Recently, one of our apple team member planted a high density apple orchard in Crisfield, MD. This showed an increase in the apple acreage for the very first time in the Tri-county area. We are also planting a high density apple orchard in Apr. 2018 using the tall spindle system to accelerate apple production. Our small apple orchard generated mass awareness about the potential of fruit cultivation in the Tri-County area. This program will revolutionize the culture of fruit cultivation in coming years on the Maryland Eastern Shore.

Specified Source(s) of Funding: SARE and 1890 Extension

Evaluation of Artificial Spur Extinction on ‘Gala’ Apple Yield and Fruit Quality in Pennsylvania

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Decreasing crop load to maximize fruit size and quality is a common management strategy for apple (Malus × domestica) production. Current thinning strategies are limited by high cost of labor, changes in chemical regulations, and variation in plant response due to unpredictable weather. Additionally, current chemical and manual thinning strategies postpone removal of fruit until post bloom. Thinning earlier in the season causes larger gains in fruit size and more effectively minimizes alternate bearing. Artificial spur extinction (ASE) is a pre-bloom method of manual thinning that minimizes a tree’s potential crop load. Experimental trials in New Zealand and Australia showed ASE to maximize the impacts, reliability, and profitability of thinning treatments. Previous research in Pennsylvania has shown that the industry standard ASE level of 6 buds remaining per square centimeter limb cross sectional area does not reduce crop load to profitable levels in our climate. In 2017, a completely randomized trial was conducted at the Penn State Fruit Research and Extension Center in Biglerville, Pennsylvania on twenty mature ‘Gala’ apple trees divided into 5 treatments. Trees were thinned to 2, 4, or 6 buds/cm² limb cross sectional area (ASE2, ASE4, and ASE6), and compared to an unthinned control. Following initial fruit set, all buds on one year old wood were removed, except one treatment which remained unaltered. Yield of fruit ≥ 6.35 cm in diameter was not significantly altered by thinning treatments (P > 0.65). However, the fruit produced by ASE4 showed a trend toward increased size, and had the highest soluble solids content (P > 0.0033). In 2018 the study will be continued, repeating the evaluation of fruit quality and yield. The addition of an early season non-chemical thinning strategy that could set potential cropload before applying other thinning treatments would be a beneficial tool for many growers in PA.

Specified Source(s) of Funding: State Horticultural Association of Pennsylvania

Toward Ecologically-based Fertilizer Recommendations That Improve Soil Quality in High-density Apple Orchards

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An asterisk (*) following a name indicates the presenting author.
Oral Presentations

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The profitability of high-density apple (Malus domestica) orchards is dependent upon obtaining sufficient vegetative growth and high fruit yields during the first three years after planting, a goal typically achieved through applying high rates of synthetically derived nitrogen fertilizer. The purpose of this project was to test the use of mulch and composts as alternative soil fertility management practices for Mid-Atlantic and Southern apple growers. Over three years, we sampled from study sites at Virginia Tech’s Alson H. Smith, Jr. Agricultural Research and Extension Center (AREC), and at the orchards of grower cooperators in Virginia and Maryland. By the third year, the mulch treatments increased tree growth at all three sites. However, using compost either alone or in conjunction with calcium nitrate did not further increase tree growth at any of the sites. Additionally, the compost applications increased plant-available soil phosphorus at the AREC site and potassium at the Maryland site, but leaf tissue mineral concentration did not increase correspondingly to the soil mineral content. Soil microbiotic communities were analyzed using the Quantitative Insights Into Microbial Ecology software. Quality checking of the more than 1.5 million bacterial sequence reads and 0.25 million fungal reads showed that the greatest effect was due to location. The dominant Operational Taxonomic Units were most closely related to Proteobacteria, Acidobacteria, and Actinobacteria. Bacterial community changes that were consistent across locations were strongly associated with root-zone Proteobacteria, increasing by 26% due to the mulch application. Evidence for fertilizer-induced changes in the relative abundance of ammonia-oxidizing bacterial family were also apparent and suggest that there are functional differences in nitrogen cycling resulting from both the mulch and fertilizer treatments. The ability to alter the bacterial community has important ramifications for the bioavailability of plant nutrients, plant-root bacterial interactions, and overall orchard sustainability.

Specified Source(s) of Funding: USDA-SARE funded research project (LS13-258)

10:45 AM – 11:00 AM

Post-bloom Application of AVG Increases Fruit Set and Yield of European Pears Produced in Two Different Climates
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Low fruit set is a major concern of pear orchards in warm-winter climates like Southern Brazil, often leading to poor yields. In major pear producing regions of the northern hemisphere, specific cultivars have a tendency for low fruit set, primarily during their early years, despite receiving adequate chill. Exogenous application of plant growth regulators (PGR) is one strategy employed to overcome this problem, though many compounds have been inconsistent. Aminoethoxyvinylglycine (AVG), an ethylene synthesis inhibitor, has shown promising results for several cultivars. The objective of this study was to evaluate different rates and timings of AVG on yield components of pear trees grown in two markedly different climates. In 2015, 20-year old ‘Packham’s Triumph’ (2 × 5 m; 1000 trees/ha) were sprayed with AVG (60 mg·L⁻¹) 7 days after bloom (DAFB). In 2016, 5-year old ‘Rocha’ (0.7 × 3.5 m; 4082 trees/ha) were sprayed with AVG (60, 80 and 100 mg·L⁻¹) 7 and 14 DAFB. Both orchards were located in Southern Brazil and were grafted on Pyrus calleryana rootstock. In Hood River, Oregon, 12 experiments were conducted between 2012 and 2016 using variable AVG rates and application timings to the cultivars ‘d’Anjou’ and ‘Comice’. Orchards varied in tree age and planting density. All experiments were arranged in randomized block designs generally comprising four to six single-tree replications. A nonionic surfactant [0.05% (v:v)] was used in all studies and solutions were sprayed to whole trees. Fruit set and yield components of ‘Packham’s Triumph’ were increased by AVG. Similarly, AVG significantly and linearly increased fruit set and yield components of ‘Rocha’ regardless application timing. However, a greater increase was observed when treatments were sprayed 7 DAFB. Fruit size was slightly reduced as AVG rate increased, probably as an indirect result of crop load. In Oregon, AVG-treated trees had significantly greater fruit set in 65% of the experiments. Full bloom applications were ineffective. Natural ethylene production rates of non-treated flowers and fruitlets peaked at 14 DAFB, irrespective of cultivar or year, and were reduced considerably by AVG. The effect of AVG on ethylene production persisted for 10–20 days after application and was rate-responsive. AVG applications between 7–14 DAFB were, generally, efficacious. Based on these results, AVG is a promising PGR to improve fruit set and yield of ‘Packham’s Triumph’ and ‘Rocha’ pears grown in Southern Brazil, and ‘d’Anjou’ and ‘Comice’ pears in the northwestern United States.

11:00 AM – 11:15 AM

Fruit Development Period Is Related to Fruit Quality Traits across a Wide Variation of Genotypes in Prunus persica
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This study examined the relationship between the length of the fruit development period and fruit quality traits in a phenotypic

An asterisk (*) following a name indicates the presenting author.

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S169

Nutrient Balance and Bitter Pit Incidence of ‘Honeycrisp’ Apple As Affected By Rootstock

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‘Honeycrisp’ apple is very susceptible to bitter pit, a physiological fruit disorder related to calcium deficiency. The main strategy for mitigating the problem has been increasing root Ca uptake and subsequent partitioning to fruit, but how rootstocks affect the balance of Ca with other nutrients and bitter pit incidence has not been examined in detail. The objectives of this work are 1) to compare fruit Ca level and its balance with other nutrients in flesh and peel tissues between ‘Honeycrisp’ and a bitter pit resistance cultivar ‘Gala’ across rootstocks; and 2) to determine rootstock effects on bitter pit incidence of ‘Honeycrisp’ in relation to tissue Ca level and its balance with other nutrients. By using mature trees of both ‘Honeycrisp’ and ‘Gala’ on four rootstocks (M.9, B.9, G.11, and G.41) in an existing field trial, we found that ‘Honeycrisp’ had much higher ratios of K/ Ca, Mg/Ca, (K+Mg)/Ca and P/Ca than ‘Gala’ in both fruit flesh and peel tissues at harvest. The higher ratios in the flesh were primarily caused by lower Ca concentrations in ‘Honeycrisp’ but those in the peel also resulted from significantly higher concentrations of K and P in ‘Honeycrisp’. Among the four rootstocks evaluated, ‘Honeycrisp’ trees on B.9 had the lowest bitter pit incidence whereas those on G.11 had the highest incidence, with trees on M.9 and G.41 being in the middle. The incidence of bitter pit in ‘Honeycrisp’ was not correlated with tissue nutrient concentrations, but corresponded well to the ratio of (K+Mg+P)/Ca in the peel. These findings indicate that the imbalance of Ca with K, Mg, and P is closely associated with bitter development and rootstock has a significant impact on bitter pit incidence.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture, Specialty Crop Research Initiative Project 2016-51181-25406 and New York Apple Research and Development Program

11:30 AM – 11:45 AM

Consumer Preferences and Quality Characteristics of Peaches Grown in Georgia

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Fruit quality characteristics and consumer acceptability can go hand in hand. Few studies in peaches have shown how both are associated or interrelated. To better characterize these associations, this study focused on evaluating 15 fresh peach cultivars that ripen from late-May to early-August in Georgia for quality characteristics and consumer acceptability. The overarching aim was to understand the quality characteristics that drive consumer likes and dislikes in the current peach varieties available in

11:15 AM – 11:30 AM

Oral Presentations

An asterisk (*) following a name indicates the presenting author.
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11:45 AM – 12:00 PM

Impacts of Hydroshield, a Novel Plant Cuticle Supplement, on Irrigation Water Reductions in Apples, Sweet Cherries and Wine Grapes

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A novel hydrophobic plant cuticle supplement (HydroShield) was developed by the authors and patented by Oregon State University. HydroShield is at least 90 μm thick and simulates xerophytic plant cuticles, slowing the movement of water out of leaves and fruit. ‘Sweetheart’ sweet cherry trees in the Dalles were subjected to 0.61 gal/hour drippers (no HydroShield) as a check, 0.61 gal/hour plus three applications of 1% HydroShield, 0.53 gal/hour (13.1% reduction) plus three applications of 1% HydroShield, and 0.42 gal/hour (31% reduction) plus three applications of 1% HydroShield. Trees were sprayed to the point of runoff with a Rears mistblower applying 100 gal of water per acre at a maximum speed of 2 mph. Trees were irrigated daily for 4 hours from 05/12/17 till harvest. Soil moisture was monitored using a neutron probe. At harvest, fruit cracking, yield and quality were evaluated for the different treatments. No differences in fruit quality or yield were observed between the different treatments. In Milton-Freewater, ‘Gala’ apples were sprayed to the point of runoff with 1% HydroShield plus 1% Cuevo® at ‘pink stage’ of bloom and again two weeks later and other trees were sprayed on the same days with 1% Cuevo® only as a check. Fruit size was measured seven times on the same five fruit on five trees each for both treatments over the growing season and again at harvest. Fruit sprayed with 1% HydroShield plus 1% Cuevo® were significantly larger by 10.6% (P < 0.001) than those fruit sprayed only with 1% Cuevo®.

In addition, ‘Braeburn’ apple trees were sprayed twice with 1% HydroShield at fruit set and again two weeks later. Trees were irrigated twice weekly for 15 hours total with four dripers per tree. Irrigation treatments included: 1) a check with drippers emitting 1 gal/hour; 2) dripper emitting 0.75 gal/hour plus HydroShield; and 3) drippers emitting 0.5 gal/hour plus HydroShield. Soil moisture was monitored at depths of 10, 20, 30, and 40 cm in the soil profile. At harvest yield per tree was estimated and fruit size and quality were evaluated for all treatments. There were no significant differences observed in the yield or fruit quality between the different treatments. Soil moisture was not significantly impacted by either of the reduced irrigation regimes compared to the untreated check. A similar trial on wine grapes using own-rooted Clone 8 ‘Cabernet Sauvignon’ was irrigated according to deficit irrigation practices and there were no differences in yield of fruit quality between those vines that received 1 gal/hour and those that received either 0.75 gal or 0.50 gal/hour plus 4 applications of 0.5% HydroShield. Soil moisture of the 1.0 gal and 0.75 gal HydroShield were similar at all depths in the soil profile. The 0.5 gal/hour soil moisture at 40 cm started drying up toward the end of the growing season. Whether or not this results in a problem in subsequent years remains to be seen. Precipitation in the Pacific Northwest occurs predominantly in the winter months and this is expected to recharge the water table but multiple years of testing are required to confirm this. Where wine grape fruit quality was concerned, only titratable acidity (TA) was significantly higher in grapes that received 0.75 gal/hour compared to the check and 0.5 gal/hour treatments. Results to date indicate that HydroShield has the ability to reduce water usage in apples, sweet cherries and wine grapes without negatively impacting yield or fruit quality. A 25% reduction in irrigation water plus HydroShield did not affect soil moisture content in ‘Braeburn’ apples, or ‘Cabernet Sauvignon’ wine grapes. A 13% reduction in irrigation water in ‘Sweetheart’ cherries also did not affect fruit quality or yield. A 50% irrigation reduction in ‘Braeburn’ apples and 31% irrigation reduction in ‘Sweetheart’ sweet cherries also did not affect yield, fruit quality or soil moisture content. A 50% reduction in irrigation water under deficit irrigation of ‘Cabernet Sauvignon’ did not affect yield or fruit quality in year one but may have an impact on the soil water table in subsequent years, which may result in lower yields and altered fruit quality. The research is ongoing.

Specified Source(s) of Funding: Oregon Best; Oregon Department of Environmental Quality
Day-neutral strawberry cultivars have expanded the potential strawberry season in cool climates from 6 weeks to 6 months. However, poor weather conditions typically experienced late in the season has made the use of protected agriculture critical for reaching this potential. Previous work has shown that the cultivars Albion and Seascape in an annual plasticulture system covered by low tunnels produce the best combination of yield and high quality fruit for local markets into the late fall season. The goal of this project was to examine the effect of spring planting date on the yield potential of these cultivars in this production system. Replicated plantings of ‘Albion’ and ‘Seascape’ were established in Ithaca and Geneva, NY in an annual plasticulture system utilizing low tunnels for weather protection. Bare root plants were installed at each site at approximately two week intervals starting 15 Apr. in Geneva (5 total planting dates) and 30 Apr. in Ithaca (4 total planting dates) and ending 15 June. Fruit was harvested from mid-July to mid-November and evaluated for marketability and mean fruit weight. The highest yields were observed from the earliest planting dates with yields trending down at the latest dates. Overall the Ithaca site had higher mean yields at approximately 525 g/plant for the 30 Apr. planting and 300 g/plant for the 15 June planting. At a planting density of 47,000 plants/ha, this translates to a calculated yield of nearly 25,000 k/ha at the early dates, which is considerably higher than typically achieved in June-bearing (short-day) production in the region. Marketable yield for ‘Albion’ and ‘Seascape’ at both locations reached a minimum of 75% and 65%, respectively, without the use of fungicides or insecticides. Higher total yield and percent marketable fruit was generally observed at the Ithaca site. Based on these trials, earlier planting is recommended for maximizing yield for day-neutral strawberry production in cool climate locations.

Biologically-based Treatments for Strawberry Growth and Disease Control in High and Low Tunnel Production in the Mid-south

Biologically-based (BB) treatments were evaluated for strawberry growth, berry yield and quality, and disease control in high tunnel (HT) and open field/lowl tunnel (OF/LT) strawberries (Fragaria xananassa) in Texas (Lubbock and Prairie View); while in Arkansas, calcium + boron foliar applications were compared to chemical fungicides. Varieties included Camino Real (CR) and Strawberry Festival (F). Bio-based treatments in Texas included Trichoderma spp., Bacillus spp., Streptomyces spp., and the plant extract Reynoutria sachalinensis. Treatments for root diseases in Texas were applied at planting and selected timings throughout the season using drip irrigation; and bi-weekly foliar applications made for Botrytis control. Regardless of treatment, the number of Rhizoctonia-infected plants at Lubbock was significantly higher in CR compared to F, and Rhizoctonia was significantly higher in HT production compared to OF/LT. In both states, and regardless of treatment, CR had significantly higher Botrytis-infected berries compared to F. At Arkansas, calcium + boron foliar applications resulted in significantly fewer Botrytis-infected berries compared to the untreated and chemical fungicide treatments, but there was no difference in marketable yield. At Lubbock, CR had significantly higher Botrytis-infected berries in OF/LT plots compared to HT. Chemical fungicide-treated plants at Prairie View had significantly lower marketable yields compared to BB treatments, while at Lubbock, no differences in marketable yields were observed. Results indicate the potential for using bio-based products and calcium + boron applications for disease control in strawberries, though more research is needed.

Specified Source(s) of Funding: Southern SARE funded all or part of this research

A Strawberry Cropping System Design for Improving Early Yield and Water Conservation and Its Economic Effect

An asterisk (*) following a name indicates the presenting author.
The majority of Florida strawberry production utilizes bare-root transplants that require large volumes of sprinkler irrigation for establishment. Although plug transplants can be established without sprinkler irrigation, they generally more than double the cost of bare-root transplants. We hypothesized that a combined use of plug transplants and heat stress management practices would be an effective strategy for water conservation and improving early yields for strawberry production. ‘Florida Radiance’ plugs were transplanted in Sept. 2016 and 2017 in Citra and Wimauma, FL on beds mulched with white-on-black plastic mulch. This treatment (WPK) utilized plug transplants that were treated with foliar applications of kaolin at 56 kg/ha immediately after transplanting and at 7 days transplanting. Plant growth and yield were compared to those of bare-root transplants set in mid-October on beds mulched with black plastic mulch and established using either standard sprinkler irrigation (BBH) or micro-sprinkler (BBM) irrigation. Irrigation water use at both Citra and Wimauma was lower with plug transplants than bare-root transplants, even though the former were transplanted earlier, due to the elimination of sprinkler irrigation for plug transplant establishment. Flowering occurred 4 and 5 days earlier with the WPK treatment than with the BBM and BBH treatments, respectively. In both years an early yield of 7.8 t/ha was obtained with WPK, which was higher than those with BBM (1.9 and 5.3 t/ha) and BBH (1.8 and 4.1 t/ha). Total marketable yield with WPK was also significantly greater than with BBM and BBH. Partial budget analysis indicated that the WPK treatment at Citra increased the net return by $7,918/acre with a consistent result obtained at Wimauma. These results will inform decision-making about cropping system modification that can be adopted by Florida strawberry growers to considerably reduce water use in an economically feasible manner.

Specified Source(s) of Funding: Southwest Florida Water Management District and Borlaug Higher Education for Agricultural Research and Development

10:45 AM – 11:00 AM

Seasonal Patterns of Root Growth in Cranberries

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Timing of root growth is of foremost importance to adjust and target production practices (e.g., irrigation, fertilization, agrochemical applications, disease control, etc.) to periods of active root growth, when uptake rates are highest, thus increasing production efficiency and reducing environmental impacts. The main objective of this study was to characterize cranberry seasonal root growth dynamics and root morphological traits, and develop a root phenology model to increase production efficiency and sustainability. A total of sixteen minirhizotron root observation tubes were constructed and installed in an angled position in the root zones of selected beds of ‘Stevens’ and ‘GH1’ in central Wisconsin during Fall 2014. Root images were recorded from Apr. 2015 to Jan. 2016, and from Apr. 2016 to Nov. 2016. During 2015 and 2016, new root production began during bloom time, and continued until after harvest. The highest rate of root production happened during and after harvest, which corresponds to the cessation of vegetative growth on the above ground portion of the plants. Root activity and production extends past harvest into mid-late fall, which might suggest that more attention should be paid to soil moisture levels during fall given that roots are still up taking water and nutrients.

11:00 AM – 11:15 AM

Applied Water Amounts, Not Timing of Leaf Removal Alters Grapevine Berry Flavonoid Content in Cabernet Sauvignon Grapevine

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Majority of viticultural areas in California are characterized by non-limiting source of solar radiation during the growing season. A consequence of such solar radiation coupled with less than crop demand precipitation received result in water deficits during ripening. There is lack of information on determining appropriate balances of canopy management and applied water amounts to produce suitable yields without compromising berry chemistry. In response, a study designed to test the interactive effects of leaf removal timing (prebloom and postfruit set, compared to an untreated control) and applied water amounts (1.0, 0.5, and 0.25 crop evapotranspiration replacement (ETc)) on Cabernet Sauvignon/110R in Oakville, CA. Stem water potential was lower in the 0.25 ETc regardless of leaf removal that led to a 40% reduction in net carbon assimilation This was mediated by a lower stomatal conductance with 0.25ETc. There was no effect of leaf removal timing on components of yield, including number of berries set. The 0.25 ETc treatment reduced berry mass and yield, but 0.5 and 1.0 ETc treatments were not different from each other. There was a significant interaction of leaf removal and irrigation on pruning mass and Ravaz Index. Reducing the applied water amounts resulted in significant effect on anthocyanin and proanthocyanidin content only when normalized dried skin mass (DSM) suggesting a concentration effect as opposed to an increase in biosynthesis. Leaf removal affected flavonol content, specifically kaempferol-3-o-glucoside both on DSM as well as a per berry basis, which conformed to existing light exposure literature. Clear skies and long periods with minimal precipitation paired with severe reduction in irrigation will have a stronger influence on berry chemistry than leaf removal practices. Our results indicated that cluster microclimate without leaf removal was already optimized. Although not as impactful, there still appears to be potential
for understanding leaf removal influence on berry physiology and its effect on vine balance in premium regions.

11:15 AM – 11:30 AM

**Pierce’s Disease Resistant Vitis vinifera L. Selections—An Innovation for Viticultural Sustainability in Alabama and the Southeast**

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Auburn University, Auburn University, AL, USA

Pierce’s Disease (PD), caused by the bacterium Xylella fastidiosa, is the major limiting factor for production of Vitis vinifera grapes in the southeastern United States. Three ‘Dog Ridge’ grafted PD resistant V. vinifera selections developed at the UC Davis, namely ‘501-12’, ‘502-01’, and ‘502-10’ were planted at the Chilton Research and Extension Center, Clanton, in 2010 to study their resistance to PD and overall performance in high PD pressure environment. The experimental vineyard is a RCBD with 6 replications and 5 vines/replication. Studies on vines’ phenoology, vegetative development, cropping potential, and fruit quality were conducted during 2012-17 seasons. All selections initiated bud break stage at the end of March and had fully developed canopies by late April. Selection ‘502-01’ had the earliest flowering season. Our results suggest all selections grew vigorously through the years of vineyard establishment. Results for dormant pruning weights revealed high vigor for all selections. Fruit of selection ‘502-10’ matures early in the season, and is harvested in mid-August, followed by ‘502-01’ harvested end of September to early-October. ‘501-12’ ripens late and is usually harvested in the second half of October. Studied selections differed in total yield per vine, but were highly productive. Cumulative yield per vine for the period 2012-2017 was the highest for the late season ‘501-12’. Early-season selection ‘502-10’ had the largest cluster size among the group with an average cluster weight of 467 g on average in 2015. Based on six years of observations, the study results are encouraging. No PD infection was detected during the period of plant establishment. The newly introduced PD resistant grape selections have the potential to improve the grape production sustainability in the southeastern region and enhance the agriculture and food systems.

**Specified Source(s) of Funding:** HATCH Alabama Agricultural Experiment Station (AAES)

11:30 AM – 11:45 AM

**Harvest Date Estimation for Hybrid Grape Cultivars in Nebraska**

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Assessing grape fruit maturity, potential wine quality at harvest, and the estimated optimal timing for harvest, can benefit both the grape grower and the winery to which the grapes may be sold. We have studied the timing of harvest over a period of 15 years for a large number of hybrid grape cultivars and correlated these times with growing degree days (GDD, base 50 Fahrenheit). These results will be reported for 16 cultivars for which GDD were recorded over a period of up to 15 years. The mean GDD will be reported, in addition to the range of extremes for earliest and latest harvest. For example, the mean GDD for ‘Marquette’ was 2757, with extremes of 2322 (an outlier?) and 2887. If the unusual extreme low is removed from the data set, the mean GDD is 2806 and nearly 80% of harvests fell between 2803 and 2887 GDD. Similarly, mean GDD for ‘Frontenac’ was 2878, with a range of 2676 to 3281, while for ‘Vignoles’, the mean was 3014, with a range of 2710 to 3374. Although harvest parameters (soluble solids, pH, TA) influenced harvest timing in several years, the data accumulated over 15 years have enabled a rough estimation of suggested harvest times for these and other hybrid grape cultivars grown in Nebraska vineyards.

11:45 AM – 12:00 PM

**Source–Sink Ratio Manipulations Affect Greatly Wine Grape Ripening and Composition at Harvest**

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Kaan Kurtural  
University of California, Davis, CA, USA  
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Canopy management and fruit load control aim to keep a balance between vine’s sources and sinks. In fact, balanced vines may produce more consistent yields and have a more even ripening. This study aims to study the relationship between source–sink ratios and important parameters for production logistics and grape quality, such as progress of ripening and grape composition at harvest. After homogenizing all vines by removing laterals and adjusting the number of shoots to 20, we tested three levels of canopy density and fruit load combined in a factorial design (3 × 3). This is, 3 canopy levels, 100%, 66% and 33% of the leaves combined with 3 fruit loads, 100%, 66% and 33% of the fruit corresponding to 30, 20, and 10 clusters per vine, respectively. Onset of ripening was sequentially delayed in 66% and 33% canopy treatments. The progress of ripening, accumulation of soluble solids and loss of acidity (increase in pH and decrease in total acidity), also occurred slower in 66% and 33% canopy treatments compared to 100% of the canopy. In fact, the time to reach commercial maturity (> 25 °Brix) was delayed 6 weeks for the 33% canopy level. Surprisingly, fruit load did not have a significant effect on the progress of ripening. When comparing
all treatments at commercial maturity, the treatment maintaining 100% of the canopy had the highest total acidity and lowest pH. Berry flavonoids at harvest were similar in the case of anthocyanins and flavonols. Contrarily, proanthocyanidins in both skins and seeds were lower in treatments keeping 33% of the canopy and 33% of the fruit. These results provide the basis for the control of the speed of ripening, and the understanding of flavonoid profile development in the different yielding strategies in wine grape production.

### Postharvest 2

**Moderator:** Christopher Watkins  
Cornell University, Ithaca, NY, USA

**10:15 AM – 10:30 AM**

**Managing Stem-end Flesh Browning, a Physiological Disorder of ‘Gala’ Apples**

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Franziska Doerflinger  
Cornell University, Ithaca, NY, USA  
Gilang Sutano  
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Christopher Watkins*  
Cornell University, Ithaca, NY, USA

A physiological disorder known as ‘stem-end flesh browning’ has recently been found in ‘Gala’ apples in the United States, Canada, Europe, and Brazil. The browning originates at the stem end but can extend throughout the fruit as severity increases. The effects of harvest date, plant growth regulators (PGRs) [aminoethoxyvinylglycine (AVG) (ReTain) and 1-methylocyclopene (1-MCP) (Harvista)], postharvest 1-MCP (SmartFresh), storage temperature (0.5 and 3 °C), and storage method [standard controlled atmosphere (CA) and dynamic controlled atmosphere–chlorophyll fluorescence (DCA-CF)] have been investigated. A Harvista spray was more effective at reducing disorder incidence than a ReTain. SmartFresh treatment had little effect. DCA-CF also delayed disorder development, but did not prevent it. Disorder incidence was slightly lower at 3 °C than 0.5 °C, indicating an advantage to using a slightly warmer storage temperature, but quality factors such as flesh firmness were reduced. The occurrence of stem-end flesh browning can be reduced by pre- and postharvest management through the use of Harvista and DCA-CF, respectively.

**Specified Source(s) of Funding:** The NY Apple Research and Development Program, AgroFresh Inc., and the USDA National Institute of Food and Agriculture, Hatch project 2013-14-483, Improving Quality and Reducing Losses in Specialty Fruit Crops through Storage Technologies (NE-1336).

**10:30 AM – 10:45 AM**

**Prediction of Bitter Pit in ‘Honeycrisp’ Apples By Inducing Symptoms before Storage**

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Jacqueline F. Nock  
Cornell University, Ithaca, NY, USA  
Lailiang Cheng  
Cornell University, Ithaca, NY, USA  
Christopher Watkins  
Cornell University, Ithaca, NY, USA

The prediction of bitter pit in ‘Honeycrisp’ apples using non-chemical methods has been investigated. Fruit from 6 different blocks in each of Hudson Valley and Western NY regions were used. Fruit were harvested at three weeks before anticipated harvest and at commercial harvest. Mineral analysis of peel tissues from the calyx-end was carried out. Replicates of fruit were either dipped or not with 2000 ppm ethephon, (2-chloroethylphosphonic acid) and bitter pit assessed at weekly intervals for 3 weeks Another set of fruit were stored at 3 °C with and without one week conditioning at 10 °C, and stored for 4 months at 3 °C + 7 d at 20 °C. Multivariate analysis shows that the passive method and ethephon dipping for fruit harvested 3 weeks before the anticipated harvest had higher correlation with the actual bitter pit after cold storage than those from minerals. The passive method is being further evaluated as a non-chemical predictor of bitter pit in ‘Honeycrisp’ apples.

**Specified Source(s) of Funding:** New York Apple Research and Development Program

**10:45 AM – 11:00 AM**

**Enhancing Postharvest Tree Fruit Quality with Functional Genomics**

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Functional genomics is an emerging technological frontier in postharvest crop management. This is driven in part by exponential growth of genomics resources for specialty crops, which include genomes and transcriptomes. These global-scale technologies are allowing insights into responses of Rosaceous tree fruit to modified atmospheres, various storage temperature regimes, and crop protectants in the postharvest period. These insights will allow researchers and producers to maximize favorable outcomes, especially with regard to crop protectant-limited production strategies. Here we report transcriptional fluxes of Granny Smith apple fruit in the early phases of long term storage in response to intermittent warming, an ostensibly organic compliant strategy that effectively reduces the incidence of superficial scald. We observed two temporally distinct classes of gene expression, which were discovered with high granularity sampling and novel analytics. This suggests that long term outcomes on the scale of months may be influenced by gene expression changes on the scale of hours.

Specified Source(s) of Funding: USDA-ARS and The Washington Tree Fruit Research Commission

11:00 AM – 11:15 AM

Utilizing Nontargeted Metabolomics to Characterize Delayed Sunscald Development on Apple
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Intense sun stress in the apple-growing region of eastern Washington state can cause delayed sunscald, a superficial postharvest peel browning disorder occurring on the sun-exposed side of apples. There is no known treatment for delayed sunscald once it occurs, so early detection of this disorder is key to avoiding losses. Polar, non-polar, and volatile metabolite extractions were performed to identify changes in peel chemistry associated with sun-induced injury prior to and during cold storage. Samples were collected from the sun-exposed and unexposed sides of the apple at harvest and at multiple timepoints throughout cold storage: 2 weeks, 1, 2, 4, 5, and 6 months. In addition, severely sunscalded peel was also collected for comparison. A principle component analysis and 2-way ANOVA was performed using Metaboanalyst, and a pairwise correlation network was generated using WGCNA, Cytoscape, and Allegro to visualize the multidimensional metabolome. Results indicated that p-coumaryl esters were higher on the sun-exposed side, indicating changes in cuticle consistency. Vinyl aldehydes and quercetin glycosides were more abundant on the sun-exposed side of the apple, consistent with their previously reported roles in sun stress, making these metabolites potential targets for early detection of delayed sunscald. Now that we have selected potential metabolic targets for delayed sunscald, a next step would be to utilize properties of these metabolites to more easily and economically detect delayed sunscald prior to symptom development.

Specified Source(s) of Funding: Washington Tree Fruit Research Commission project AP-16-102

11:15 AM – 11:30 AM

Alterations in Peel Secondary Metabolism Are Associated with Superficial Scald in Apples
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Superficial scald is a peel browning of susceptible cultivars, such as ‘Granny Smith’ developing during prolonged cold storage. The ethylene perception inhibitor 1-methylcyclopropene (1-MCP) and the antioxidant diphenylamine (DPA) are used to effectively manage the disorder. The current study identifies changes in peel metabolism that are associated with the development of superficial scald throughout storage. Postharvest applications of 1-MCP and DPA were performed on ‘Granny Smith’ apples, and peel tissue was collected following harvest and throughout six months of storage. Nonpolar metabolites were extracted and analyzed using LC-MS and GC-MS to characterize metabolic divergence between control and treated fruit. Sesquiterpenes, α-farnesene oxidation products (conjugated trienols), sesquiterpene esters, and p-coumaryl esters differentially accumulated among control, DPA, and 1-MCP treated apples. Conjugated trienols were produced in high levels in control fruit prior to the development of visible scald symptoms as compared with DPA and 1-MCP treated fruit; this trend was also reflected in two compounds identified as fatty acyl esters of conjugated trienols. Levels of fatty acyl esters of p-coumaryl alcohol increased throughout storage; accumulation was greater in DPA treated peel and diminished in 1-MCP treated peel as compared with controls. Compounds tentatively identified as p-coumaryl conjugates of triterpenoic alcohols displayed the opposite trend, accumulating at higher levels in 1-MCP treated peel. Widespread changes in the metabolic profile of epidermal
Fruit maturity at harvest impacts quality and occurrence of storage disorders, but most maturity indicators are inaccurate for ‘Honeycrisp’ apples. The Delta Absorbance™ (DA meter) measures fruit peel absorbance at 670 and 720 nm and calculates the ratio as IAD units. Fruit were randomly harvested from 3–5 trees of ‘Honeycrisp’ at two harvest dates in 2015, and three in 2016, and 2017. Each harvest was replicated three times. ‘McIntosh’ was included in 2016. The IAD was measured on two sides of each apple at harvest and after 1.5 months cold storage at 1 °C, along with storage disorders. Starch index, SSC and flesh firmness was measured on 5–10 fruit from each IAD group (0–0.19, 0.20–0.39, 0.40–0.59, etc.). The IAD in ‘Honeycrisp’ decreased with advancing maturity in all 3 years. By the third harvest, IAD had decreased to zero in some apples. The IAD was lower in 2016 than in 2015 and 2017. Mean IAD ranged from 0.6–0.8 during the second harvest, which corresponded with peak commercial harvest. Mean IAD of ‘McIntosh’ at peak harvest was 1.8. Within a harvest date, IAD in ‘Honeycrisp’ varied substantially, as much as 1.4 IAD units, compared with ‘McIntosh’, which varied by 0.8 IAD units within a harvest date. Starch index was not related to IAD in ‘McIntosh’. Starch index in Honeycrisp was negatively related to IAD during both harvest dates in 2015, during the first and second harvests in 2016, and during the second in 2017. Bitter pit did not occur in either ‘Honeycrisp’ in 2015 or in ‘McIntosh’ in 2016. Bitter pit incidence did not vary with IAD in 2016 or 2017. In 2015, soft scald was severe in fruit from the 2nd harvest, and incidence decreased with decrease in IAD. In 2016, soft scald incidence was severe in fruit from the second and third harvest. In fruit from the second harvest, soft scald decreased with decrease in IAD, but no relationship occurred with the other two harvests. However, when data from all three harvests were pooled, soft scald incidence was negatively related to IAD consistent with the effect of maturity. In 2017, soft scald incidence was not related to IAD in fruit from the second or third harvest, but in fruit from the first harvest, it increased as IAD decreased.
this initial P can be reduced 35% with lime, 54% with micronutrients, or 78% when amending pine bark with both dolomite and micronutrients. Once the CRF released (≈ 20 days), available or leachable P can be reduced by more than 50% for > 30 days when amending with dolomite with or without micronutrients. These data can be used to further refine P fertility when producing containerized woody nursery crops.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-2372

10:35 AM – 10:55 AM

Reducing Water and Pesticide Movement in Nursery Production

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Nurseries produce a large number of plants in a concentrated area and aesthetics are a key component of the product. In order to produce crops in this fashion, high inputs of water, nutrients and pesticides are typically used. Container nursery production further increases the inputs, especially water, since container substrates are designed to quickly drain and the most effective method to irrigate large numbers of plants in containers (up to a certain size) is with overhead irrigation. As irrigation and pesticides are broadcast over the crop and the crop is limited to the container, a large proportion of water or pesticide may land on non-target areas. Water is the primary means of pesticide movement in nursery production. This presentation will discuss water and pesticide dynamics and management strategies to conserve water and reduce pesticide and water movement in container nursery production.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-2372

10:55 AM – 11:15 AM

Effect of Plant Available Water Reduction on Two Yellow Garden Mum (Chrysanthemum morifolium) Cultivars

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The effect of reducing substrate moisture availability on the growth of two yellow garden mum (Chrysanthemum morifolium) cultivars (Chelsea and Ursula) was investigated in a greenhouse study. Seedling of both cultivars were transplanted and grown into 8-inch pots filled with two soilless substrates—Sunshine Gro mix—LC1 (70% peat moss:30% perlite) and a wood fiber (WF) substrate (60% peat moss:40% wood fiber). The experiment was laid out in randomized complete-block design with four replications and consisted of three irrigation treatments. Moisture release curve for the substrates used in the study was developed using the Hyprop device (METER Group Inc., Pullman, WA). Based on the volumetric water content (VWC) vs. matric potential (MP) relationship observed, three VWC values [45% (control), 35% (IT1), and 25% (IT2)] were selected as set-points for treatments in order to apply progressively less irrigation water. VWC and MP measurements were obtained with GS-1 and MPS-6 sensors (METER Group Inc.) on a 5-minute basis using Em50R data loggers (Meter Group Inc.). Recorded data was transmitted through a basestation to Sensorweb™ software (Mayim LLC., Pittsburgh, PA). For each substrate, VWC readings from two plants (one from each cultivar) in each experimental unit were averaged on a 15-minute basis. Irrigation was applied for 15-second durations whenever the average VWC sensed was below the corresponding set-point using PlantPoint™ (METER Group Inc.) control data loggers that were connected to solenoid valves. The substrate VWC for each substrate was maintained within a very narrow range of the set-points throughout the study. Irrigation application was recorded with flowmeters (Model 25, Badger Meter Inc., Milwaukee, WI). Plants were destructively harvested at full maturity and data on growth index (GI), leaf area (LA), leaf fresh mass (LFM), leaf dry mass (LDM), flower number (FN), flower fresh mass (FFM), flower dry mass (FDM), stem fresh mass (SFM), stem dry mass (SDM), total shoot mass (TSM) and root dry mass (RDM) were obtained. Analysis of harvest data showed that there were no significant differences between irrigation treatments for all measured parameters for ‘Chelsea’ in the WF substrate. However, significant differences in the parameters GI, LA, LFM, FFM, FN, SFM, SDM, TSM and RDM were observed for ‘Ursula’, with the IT1 and IT2 treatments resulting in plants with less vigor. Irrigation application volume was 16.6% and 41.1% less for the IT1 and IT2 treatments compared to the control. In the LC1 substrate, only GI and FN were significantly different between irrigation treatments for ‘Chelsea’; whereas only GI was significantly different between irrigation treatments for ‘Ursula’. Volume of irrigation water applied was 33.0% and 33.7% lower for the IT1 and IT2 treatments as compared to the control. The results observed indicate differences in the moisture release properties of the two substrates and possible differences in drought resistance of the two cultivars.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-2372

11:15 AM – 11:35 AM

Irrigation Practices and Pathogen Infection Potential: Balancing Reduced Water Use with Oomycete Disease Risk in Containerized Nursery Production

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An asterisk (*) following a name indicates the presenting author.
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Oral Presentations

Lorence Oki*
University of California, Davis, CA, USA

Irrigation Runoff Water-Borne Plant Pathogens from Captured Slow Sand Filters Are Effective in Removing

11:35 AM – 11:55 AM

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-22372

Slow Sand Filters Are Effective in Removing Water-Borne Plant Pathogens from Captured Irrigation Runoff

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Slow sand filters (SSF) are an old technology used to produce drinking quality water, but there are few systems installed in the United States for horticultural purposes. Operational costs, other than pumping the water to the SSF, are low since chemical or energy inputs are not needed. Filters consist of a sand bed that serves as a substrate for a biofilm of microorganisms to develop. As water flows through the sand bed, these microorganisms degrade pathogens and other pollutants. We were interested in the capacity of these filters to remove different kinds of plant pathogens from captured irrigation run off and this report reviews our work on the capacity of these filters to remove Phytophthora ssp., Fusarium oxysporum, and Tobacco mosaic virus. To determine if SSFs established against Phytophthora capsici were capable of removing other Phytophthora species, one set of SSFs was set up at University of California, Davis (UCD) and exposed only to P. capsici. At the same time, another set of SSFs was set up in Santa Cruz County and provided water from Lompico Creek which was known to contain P. ramorum, the pathogen that causes Sudden Oak Death, in addition to other species of Phytophthora. After 30 days, all of the SSFs removed Phytophthora and the filters at UCD were moved to Santa Cruz Co. and provided creek water. Phytophthora was not recovered from water that flowed through the SSFs from UCD after relocation. To see if SSFs can remove a newly introduced pathogen, a set of SSFs was exposed to P. capsici and a second set was exposed to F. oxysporum. After 7 weeks, the SSFs removed P. capsici, but the other set of SSFs did not remove F. oxysporum. Then, the SSFs exposed to P. capsici were now provided F. oxysporum and the SSFs previously provided F. oxysporum were supplied with P. capsici. P. capsici was immediately removed from the SSFs, but F. oxysporum was not removed from the other set of SSFs, which was expected. To simulate a pump failure, water was not provided to the filters
for 7 days. After water flow was restarted, *P. capsici* removal resumed immediately, but there continued to be no removal of *F. oxysporum*. Another class of pathogens of concern are plant pathogenic viruses. In our tests, the SSFs were able to remove *Tobacco mosaic virus* from inoculated runoff water after 6–9 weeks of exposure.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-22372

11:55 AM – 12:15 PM

**Nutrient and Pathogen Remediation Using Floating Treatment Wetlands**

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Floating treatment wetlands (FTWs) are a constructed wetland technology that directly exposes roots of plants to the water column. This exposure of water to the root system leads to an increase in nutrient uptake and remediation and a possible decrease in plant pathogen loading. Research at Clemson University was conducted between 2015 and 2018 to assess a variety of plant species for both their nutrient remediation efficacy, specifically nitrogen (N) and phosphorus (P), as well as their susceptibility to *Phytophthora* spp. Five species of plants were trialed for nutrient remediation and pathogen susceptibility (*iris ensata, Pontederia cordata, Agrostis alba, Carex stricta*, and *Panicum virgatum*). An additional three species were assessed for nutrient remediation only (*Andropogon glomeratus, Canna ‘Firebird’, and Juncus effusus*) and an additional two species were assessed for pathogen susceptibility only (*Sagittaria latifolia* and *Typha latifolia*). Plants for nutrient remediation analyses were suspended using a floating mat and aerator cups in a mesocosm study, while plants for pathogen susceptibility analyses were floated in 2.5 L pots. Plants were exposed to either elevated levels of nutrients (5 ppm N or 12 ppm N) or one of five species of *Phytophthora* (*P. citrophthora, P. cinnamomi, P. cryptogea, P. nicotianae*, and *P. palmivora*) in a 10 ppm N nutrient solution. While *C. ‘Firebird’*, *A. alba*, and *P. cordata* removed greater than 50% of nitrate from the system, maximum phosphorus removal was 28% and 12% with *P. virgatum* and *C. ‘Firebird’*, respectively. While there were no detected root infections by *Phytophthora* spp. during the 2016 pathogen trial, roots of *C. stricta, P. virgatum*, and *T. latifolia* were found to be infected in the 2017 trial. Both *I. ensata* and *P. cordata* show promise for FTW installations in nursery and greenhouse applications due to their nutrient remediation capabilities and apparent pathogen resistance. Further testing is needed to determine pathogen remediation efficacy of the trialed plants, as well as nutrient remediation efficacy and plant pathogen susceptibility of other aquatic plant species.

Specified Source(s) of Funding: USDA-NIFA-SCRI # 2014-51181-22372

11:30 AM – 12:45 AM

**Effect of Ethephon, Abscisic Acid and Methyl Jasmonate on Fruit Ripening in Rabbiteye Blueberry**

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Ripening in blueberry fruit occurs over an extended period requiring multiple harvests thereby increasing the costs of production. Several phytohormones contribute to the regulation of fruit ripening. Certain plant growth regulators (PGRs) can alter the content, perception or action of these phytohormones, potentially accelerating fruit ripening and concentrating the ripening period. The effects of three such PGRs on fruit ripening were evaluated in rabbiteye blueberry (*Vaccinium virgatum*) cultivars ‘Premier’ and ‘Powderblue’. Application of ethephon, an ethylene-releasing PGR, at 250 mg·L⁻¹ when 30 to 40% of fruit on the plant were ripe, accelerated ripening by increasing the proportion of blue (ripe) fruit within 4–7 d after treatment in both cultivars. Ethephon applications did not generally alter fruit quality characteristics at harvest or during postharvest storage, except for a slight increase in ‘Powderblue’ fruit firmness and titratable acidity after 15 d of postharvest storage. Abscisic acid (600–1000 mg·L⁻¹) and methyl jasmonate (0.5 mM–1 mM) applications generally did not alter ripening characteristics in either cultivar. These applications also had little effect on fruit quality characteristics at harvest and during postharvest storage. None of the above PGR applications affected the development of naturally occurring postharvest pathogens that developed during storage. Together, data from this study indicate that ethephon has the potential to accelerate ripening in rabbiteye blueberry fruit allowing for a potential decrease in the number of fruit harvests.

Specified Source(s) of Funding: Southern Region Small Fruit Consortium

11:45 AM – 12:00 PM

**Spray Thinning at Bloom Increased Large Fruit Yield of ‘Improved French’ Prune**

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An asterisk (*) following a name indicates the presenting author.
Prunes (*Prunus domestica* L. Batch) production in California is limited to a single cultivar, ‘Improved French’. The crop is grown for the processed (dried) market with larger fruit, suitable for pitting, delivering higher grower return per pound than small fruit, which is used only for juice or concentrate production. Prune thinning is done by modified harvester more than a month after full bloom, when the fruit reach sufficient mass for mechanical removal. However, shaker thinning is not practiced by all growers and excessive production per acre of mostly small, lower value fruit is not uncommon. Return bloom can be limited in years following heavy crops, producing inconsistent production from year to year, harming grower income and industry marketing strategies. In 2015, a field study was begun in a mature, high yielding prune orchard in Sutter County, CA, to test the hypothesis that bloom thinning with a caustic spray material would deliver more consistent production of large ‘Improved French’ prunes than unsprayed trees. For three seasons, 2015–17, potassium thiosulfate (KTS) at 1.0 v/v or 2.0 v/v was applied at 25% and again at 80% full bloom in a volume equivalent to 1871 l/ha to four (2015) or five (2016–17) trees per treatment. The experiment followed a randomized complete block design with blocking by trunk cross-sectional area and using a single tree per treatment per block. At commercial harvest, fresh fruit weight per tree was measured and a 2 kg subsample taken for drying at a commercial dehydrator. Whole tree dry (18% moisture) fruit yield per each treatment tree was determined using the dry to fresh weight ratio of the subsample. Dry fruit count per kg was determined for each subsample and then scaled up to determine large (<36 dry fruit/kg) fruit size yield for each tree. Conditions at bloom in 2016 resulted in crop failure, but large commercial crops were produced in 2015 and 2017. In both of those years, KTS bloom spray treatments did not significantly affect dry fruit yield (kg/tree), but 2% KTS bloom sprays significantly (*P* = 0.05) increased yield of large fruit per tree over that of unthinned trees. Bloom sprays of 1% KTS significantly (*P* = 0.05) increased large fruit production in 2015 compared to control trees, but not in 2017. These results indicate a potential application for caustic spray thinning in ‘Improved French’ prune and encourage further research.

_Specified Source(s) of Funding: California Dried Plum Board_

12:00 PM – 12:15 PM

**Effects of ABA or Abz Application on Anthocyanin and Sugar Biosyntheses in Grapes**

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We examined the effects of ABA or abscinazole (Abz) application, which is ABA 8'-hydroxylase inhibitor, on anthocyanin and sugar biosyntheses in ‘Kyoho’ (*Vitis labrusca × V. vinifera*) grapes. Three groups were created in this study. ABA (first group) was applied to grapevines and Abz (second group) was applied to grapevines at véraison and 7 days after véraison. The third group was the untreated control. Grape berry skin was sampled at 15, 30, 45, 60 days after treatment (DAT). The anthocyanin and glucose, fructose, and sucrose concentration, anthocyanin biosynthetic genes, and sucrose transporter gene expression levels were analyzed. ABA application significantly increased anthocyanin concentrations but Abz application increased those concentrations significantly only at 15 DAT. Abz application increased glucose, fructose, and sucrose concentrations in the skin higher than the untreated control and ABA treated group. Moreover, Abz application up-regulated VvSUT expression levels. From these results, ABA application may induce anthocyanin accumulation in ‘Kyoho’ grape berries, and Abz application may enhance sucrose transportation and increase sugar concentrations.

**Genetics and Germplasm 4**

_Moderator: Stan Hokanson_

University of Minnesota, Saint Paul, MN, USA

1:45 PM – 2:00 PM

**First Clear Evidence of Population Structure in Cornus Kousa (Asian Dogwood)**

Marcin Nowicki*
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Asian dogwood (*Cornus kousa*), closely related to North American-native flowering dogwood (*C. florida*), is an economically important ornamental understory tree. Many *C. kousa*-based cultivars, breeding lines, and hybrids with *C. florida* have been developed and commercially released in the United States due to their attractive features and desirable (a)biotic stress tolerance. To assess the species genetic diversity, samples of *C. kousa* gDNA from 130 plants of non-cultivated Asian origin (China,
Population Analysis of *Erysiphe Pulchra*, Pathogen of *Cornus Florida*

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*Coronius florida* (flowering dogwood) is an understory tree native to eastern hardwood forests of the United States (U.S.) and utilized as a popular ornamental landscape tree. In the mid-1990s, dogwood powdery mildew (*Erysiphe pulchra*) reached epidemic levels throughout the *C. florida* native range causing a drastic rise in production costs. Dogwood powdery mildew is an obligate biotrophic fungus of some big-bracted dogwoods (*C. kousa*, *C. florida*, and *C. nuttallii*). The pathogen exhibits with the white mycelium, conidiophores, and conidia on the adaxial surface of leaves. Disease symptoms include stunted growth of trees, necrosis of young leaves, red pigmentation near infected areas, and decreased flower and fruit production. During the late 1990s, both sexual and asexual stages of *E. pulchra* were regularly observed, but in recent years, chasmothecia have been rarely detected. Utilizing 15 microsatellite loci, we analyzed 174 *E. pulchra* samples collected from symptomatic *C. florida* leaves to assess genetic diversity and population structure of the pathogen. After clone correction, which removed 77 *E. pulchra* individuals, a total of 97 multilocus haplotypes (MLH) were used for further population analyses. Data were grouped and analyzed as either two sub-populations or eight sub-populations based on geographical sampling. Our study indicated low genetic diversity and a lack of population structure of *E. pulchra* in the eastern U.S. The index of association differed significantly from 0, signifying asexual or clonal reproduction. Our demographic history data indicated a population bottleneck among the sampling locations. These findings strongly suggest that *E. pulchra* has become almost exclusively clonal since 1995, which lends support to the hypothesis that *E. pulchra* is an exotic pathogen introduced to North America.

Specified Source(s) of Funding: USDA/ARS number 58-6062-6-002

2:00 PM – 2:15 PM

**Genetic Diversity of Minnesota’s Most Endangered Tree Species, Eastern Hemlock**

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Eastern hemlock (*Tsuga canadensis* (L.) Carr), a common conifer in the eastern United States, exists on the northwestern extent of its native range in Minnesota. The species has always been rare in the state, possibly due to the cold, dry climate, but it has declined in the last century due to pressures from fire and logging. Eastern hemlock is currently considered to be the most endangered tree species in Minnesota, with less than 40 mature trees left in native stands in the northeastern region of the state. Additionally, there are trees of known native origin at the Minnesota Landscape Arboretum and trees of unknown, but possibly native origin at various municipal and state parks across the state. We used eight previously described microsatellite markers derived from *Tsuga canadensis* to investigate the genetic diversity and differentiation of disjunct native populations and cultivated trees in Minnesota and to determine the

An asterisk (*) following a name indicates the presenting author.

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origin of cultivated trees of unknown provenance. We collected foliage samples for DNA extraction from all known native trees and select cultivated trees in Minnesota, trees in the Great Lakes region and trees from North Carolina, the center of species diversity. Additionally, over the course of two years we collected and grew seed from 17 Minnesota native trees and 4 trees of wild provenance from the Minnesota Landscape Arboretum. Considering only native adult trees, population differentiation and inbreeding as measured by Slatkin’s were relatively high ($R_u = 0.123; \text{RIS} = 0.219$). Structure and Principal Component Analysis revealed Minnesota native populations to be genetically distinct from main range populations in Michigan and North Carolina. Paternity analysis of seedlings revealed few statistically significant mother-father pairs, although likely pollen parents often included non-native trees. Results from this research are being used to inform decisions about the conservation and management of existing native and cultivated trees. This includes using select native trees as seed sources for restoring populations and supplying the region’s landscape nursery industry with native sourced plant material. Although these disjunct populations are subject to potential genetic risks posed by inbreeding, they may prove useful as a source of genetic resources for problems such as the hemlock wooly adelgid (Adelges tsugae Anaand.) currently killing large numbers of trees in eastern U.S. populations.

Specified Source(s) of Funding: MN Ag Expt. Station

2:30 PM – 2:45 PM

**Evaluation of Genetic Diversity and Stability of Colocasia Cultivars Using ISSR**

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Using 44 ornamental *Colocasia* cultivars planted at Stephen F. Austin State University (Nacogdoches, TX), cultivar assessment, genetic diversity, stability, and relationship were examined with banding patterns produced from Inter-simple sequence repeat (ISSR) markers. Comparing banding patterns of vegetatively propagated clones of each cultivar, genetic stability was examined. Unweighted pair group method with arithmetic mean (UPGMA) and principal coordinate analysis (PCO) were performed to examine genetic relationship that can explain a need for the new classification *Colocasia gigantea* and recent movement of re-classifying *Colocasia antiquorum*. Average Shannon’s diversity index for all loci was found to quantify genetic diversity. The genetic stability analysis confirmed all 44 cultivars commonly found in market have identical genetic characteristics. The genetic relationship analysis supports the new classification of *Colocasia antiquorum* but does not strongly support the need for reclassification of *Colocasia gigantea* based on our results. Shannon’s diversity index suggested that 44 ornamental *Colocasia* cultivars have high gene pool.

2:45 PM – 3:00 PM

**Molecular Basis Underpinning Leaf Coloration and Defoliation in Transgenic Ficus Lyrata Plants**

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University of Florida, Mid-Florida Research and Education Center, Apopka, FL, USA

*VvmybA1* is a gene derived from grape (*Vitis vinifera*) and belongs to the MYB gene family. Our previous study demonstrated that overexpression of *VvmybA1* caused accumulation of anthocyanin in leaves of transgenic *Ficus lyrata*, a popular woody ornamental plant. The purple-leaved *F. lyrata* was also prone to leaf defoliation in greenhouse. This study was undertaken to analyze molecular mechanisms underpinning the leaf coloration and leaf defoliation. Transcriptome profiling derived from purple-leaved *F. lyrata* overexpressing *VvmybA1* was compared to that of non-transformed, green-leaved plants. The results showed that the accumulation anthocyanin was caused by the upregulation of genes encoding UDP glucose flavonoid 3-O-glucosyltransferase, UDP-hamnose-anthocyanidin-3-glucoside rhamnosyltransferase, chalcone synthase and chalcone isomerase, which are key to anthocyanin biosynthesis. However, genes associated with photosynthesis and energy supply were downregulated. Furthermore, genes involved in defoliation, including beta-glucosidase, shikimate O-hydroxy cinnamoyl transferase and anthocyanidin reductase were all downregulated. The downregulation of these genes may explain why purple leaves are more prone to defoliation. The defoliation is undesirable as *F. lyrata* has been widely used as a house plant for interiorscaping. This study indicates that overexpression of a particular gene can significantly affect other valuable traits in ornamental plants. Thus, subsequent selection should retain the novel phenotype without compromising other traits.

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Commercial Horticulture 2

Moderator: Vanessa Gordon
USDA-ARS SEA Sugarcane Field Station, Canal Point, FL, USA

1:45 PM – 2:00 PM

Improving Establishment of Hops by Optimal Selection of Cultivars, Plant Materials, Nitrogen Fertilization, and Plant Spacing in Florida

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Hops (Humulus lupulus L.) have been gaining interests as a specialty crop for Florida’s rapidly growing craft beer industry. Although hops are adapted to temperate climates, previous studies demonstrated that some hop cultivars have potential for viable production even under Florida’s subtropical climate. Field experiments were conducted over the two seasons (2016–2017) to determine the optimal cultivar, planting material, nitrogen (N) fertilization rate, and in-row plant spacing for improving the establishment of hops in Florida. In the first season, rhizomes were planted in April on native, deep sand soil in a 6-m high trellis system. Treatments were factorial combinations of two cultivars (‘Cascade’ and ‘Chinook’), two nitrogen (N) rates (0.84 and 1.1 kg/ha/day), and three in-row plant distances (76, 91, and 107 cm). Harvests were performed 10 times between June 1 and Dec. 2, 2016. The maximal bine length was similar regardless of cultivars and other treatments (282 to 321 cm). By contrast, bine number recorded during the mid-harvest was 186% greater for ‘Cascade’ than ‘Chinook’ (4.1 vs. 1.4 bines/plant). Cone yield showed significant cultivar x N rate interaction effects: ‘Cascade’ increased yield with increasing N rate by 33% (333 vs. 442 kg/ha on a fresh-weight basis), whereas yield of ‘Chinook’ was very small regardless of N rates (40 kg/ha). In both cultivars, in-row plant spacing did not have significant effects on both bine growth and yield. Major drawbacks associated with rhizomes included low emergence rates (57% to 67%) and the infection of apple mosaic virus confirmed immediately after planting. Because of these drawbacks, the hop yard was reestablished using tissue culture seedlings of ‘Cascade’ in the second season. Compared with the plant growth in the first season, tissue culture plants had a relatively high survival rate (97%), but less vigorous growth with up to 176 cm in bine height and 3.7 in bine number. Cone yield was 322 kg/ha on a fresh-weight basis. The results suggest that ‘Cascade’ has a much higher yield potential than ‘Chinook’ in Florida, and that bine number is an important yield-related trait. Furthermore, the first season yield of ‘Cascade’ can be maximized by optimizing N fertilization rate. To establish a virus free hop yard with uniform stands, tissue culture seedlings are recommended than rhizomes.

Specified Source(s) of Funding: 2017 Florida Specialty Crop Block Grant # USDA-AMS-SCBGP-2017

2:00 PM – 2:15 PM

Identifying Bulb Fennel Cultivars Suitable for Production in Northwest Washington

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Farmers in northwest Washington are searching for new crops that are well suited to the region’s moderately cool environment, have good market value, and fill a crop rotation niche that supports the production of the primary high-value specialty crops grown in the region. Bulb fennel (Foeniculum vulgare) fits these criteria. Bulb fennel is a cool-weather crop that is produced predominantly in Sicily, which has a climate similar to northwest Washington during the fennel production season. The average temperature in Sicily during bulb fennel seeding/transplanting (Nov.–Dec.) is 13 °C, and during harvest (Mar.–May) is 17 °C, which is similar to the growing climate of Mount Vernon, WA, during the spring (11 °C) and summer (16 °C). This study tested the yield and quality of 11 bulb fennel cultivars in northwest Washington in Summer 2017. The experimental design was a randomized complete block with 4 replications and 20 plants per plot, and the planting design was a double row on a raised bed with drip irrigation covered with black plastic mulch. All cultivars were seeded in the greenhouse on 2 May and transplanted to the field 14 June. The average emergence was 91%, with Orazio, Solaris and Zefa Fino with the lowest emergence (85% on average). The days from seeding to first harvest was 148–150 days for all cultivars except Bronze, which did not form bulbs. All cultivars except Florence and Zefa Fino reached marketable bulb size (bulb circumference ≥ 16 cm). Solaris and Tauro produced the largest bulbs, with average bulb weight of 400 g. Finale and Tenace produced more marketable bulbs (80%) than other cultivars. There were no significant differences among cultivars in total soluble solids (TSS), tenderness and branching; and internal cracking was also similarly minimal for all cultivars. Perfection had the lowest basal cracking level than other cultivars, but all bulbs were considered marketable. These preliminary results indicate northwest Washington has the potential to produce high-quality bulb fennel. This study will be repeated in 2018 and will also include a second seeding/transplant date of 2 weeks later than the current study.

An asterisk (*) following a name indicates the presenting author.
2:15 PM – 2:30 PM

**Increasing Artichoke Yields By Cultivar Selection and Optimization of Nitrogen Fertilization Rates and In-row Spacing in Florida**

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Globe artichoke (Cynara cardunculus var. scolymus) is emerging as a new specialty crop in Florida because of its high potential production value. However, suitable cultivars and production guidelines have not been established. Two field experiments were conducted under a subtropical climate in West Central Florida. To overcome chilling requirements of artichoke, plants were treated with gibberellic acid at 49 g·ha⁻¹ three times during the vegetative growth stage. First, we evaluated six cultivars and identified that marketable yield was highest in the order: ‘Imperial Star’ (7.25 t·ha⁻¹) > ‘Opal’ (4.30 t·ha⁻¹) > ‘Green Globe’ (3.85 t·ha⁻¹) > ‘Colorado Red Star’ (0.99 t·ha⁻¹) > ‘Purple Romagna’ (0.64 t·ha⁻¹) > Madrigal (0 t·ha⁻¹). Marketable yield of ‘Imperial Star’ was significantly higher than that of three lowest-yielding cultivars. The yield variation was due mainly to bud number per plant, with ‘Imperial Star’ producing the highest number of buds (3.9/plant) among all cultivars. Using ‘Imperial Star’, factorial combinations of five nitrogen (N) fertilization rates (106, 157, 206, 257, and 307 kg·ha⁻¹) and three in-row plant distances (76, 91, and 107 cm) were tested. Overall, N rates had stronger significant effects than plant spacing. For all in-row plant distances, plant width and leaf N concentration increased linearly with N rates. Marketable yield also increased linearly with N rates (1.73 to 5.13 t·ha⁻¹), averaging across in-row plant distances. Although area-based yield was unaffected by plant spacing, yield on a plant basis increased with increasing plant spacing. In addition, the linear trends of measured variables became generally stronger with increasing plant spacing, indicating more intense plant competition at narrow plant spacing. In the two trials, seedlings were transplanted on 2–6 Oct. 2017, and harvests were performed 8–12 times between 31 Jan. and 22 Mar. 2018, when market prices of artichoke are generally highest because of the low domestic supply. These results suggest that ‘Imperial Star’ is the most suitable cultivar to the subtropical growing conditions of Florida. Marketable yield of this cultivar can be maximized by adopting high N fertilization rates. Importantly, the enhanced earliness may support viable artichoke production in Florida.

*Specified Source(s) of Funding: 2016 Florida Specialty Crop Block Grant # USDA-AMS-SCBGP-2016*

2:30 PM – 2:45 PM

**Field Measurement and Qualitative Inquiry Indicates Need for Reevaluation of On-farm Food Loss Estimates in North America**

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Estimates of food loss and waste in developed countries including the United States suggest the most impact to the triple bottom line of society, environment, and economy occurs at the consumer level. Hence, research and other initiatives have emphasized consumer campaigns, aiming to reach national and global targets. Food loss at the origin of the supply chain, however, is considered low volume or low value, not garnering much attention, even as approximations that inform these estimates are decades old and not rooted in field measurement. Several projects centered on the farm level aimed to understand whether the available estimates are accurate. Explorations have focused on modern vegetable production systems over grower estimates collected through interviews. The method used is similar to determining harvest potential at the start of the season, but has been applied after the growers’ primary harvest. Considering edible vegetable crops alongside what is considered acceptable in the marketplace, an evaluation of eight crops in seventy North Carolina fields determined the average loss is equivalent to 36% of the marketed yield, much higher than the 10% used in global calculations. Qualitative inquiry with vegetable growers confirmed no measurement of losses is routine, and the confidence they have in estimates they have provided is low. Solutions that aim to reduce losses in the field have been explored, with mixed success. Results from these studies using field measurement indicated there is a need for reevaluation of the estimates used to report farm level losses in the U.S. supply chain.

*Specified Source(s) of Funding: USDA-SARE*

2:45 PM – 3:00 PM

**Exciting Youth about Careers in Agriculture and STEM**

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Manatee County has over 313,000 acres of production agriculture and ranks 7th in Florida in agricultural sales. However, an aging workforce threatens the future viability of these enterprises. Therefore, it is vital to inspire our youth to consider careers in agriculture. An annual youth field day was held to help inspire youth interested in agriculture. The objectives of the field day were to provide the opportunities for youth to experience sci-
ence, technology, engineering, and math (STEM) programs while exposing them to different facets of agriculture. The methods used for the field day included tours of plant nurseries/farms/research centers, presentations, hands-on activities, and educational games. Seventy-two youth of diverse backgrounds participated. A survey was used to evaluate the day and a six-month follow-up was utilized to measure behavior change. There was a 39% increase in knowledge about agricultural science, a 36% increase in knowledge pertaining to commercial agriculture, and a 28% increase in an interest in pursuing a career in agriculture. Eighty-eight percent felt that buying food locally was a good idea and had convinced their parents to do so. Sixty percent realized that many insects are beneficial and now try to preserve them in their homes and gardens. This annual program has been a success preparing today’s youth toward becoming an integral member of agriculture in Manatee County and elsewhere.

3:00 PM – 3:15 PM

Optimizing Return on Investment: Maintaining Scientific Integrity While Balancing the Strategic Relationship Shared between the USDA Agricultural Research Service and Its Stakeholders—A Case Study

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The Canal Point Cultivar Development Program incorporates five phases through which clones of sugarcane (complex hybrids of Saccharum spp.) are progressed. Each stage (i.e., seedlings, Stages 1, 2, 3, and 4) offers an added level of selection stringency designed to focus on the ultimate release of superior cultivars with both agronomically desirable traits (e.g., tonnage and/or sucrose, etc.) and abiotic/biotic tolerances to growth pressures experienced in the Everglades Agricultural Area. The sampling and trialing of these stages, however, is tied directly to the harvesting season of the commercial processes occurring concurrently in the October through March timeframe. Trial clones are typically sampled earlier (i.e., September) than what would occur in production, and subsequent selection for advancement to the next developmental stage based upon this premature data. A study was conducted over a three-year span to investigate the ramifications of this early sampling on the Stage 2 developmental trial stage of the muck-soil program. The study included annual sugar sampling at both early (i.e., normal trial sampling; September) and late (i.e., optimal harvest sampling; late February to early March) harvesting dates; and comparing these BRIX and sugar data against those taken for the clones in the previous Stage 1 and succeeding Stage 3 stages. The results indicate: a) that the majority of elite clones are continually overlooked for advancement based on this premature data; b) only ~12% of the clones selected in the autumn maintain their performance over the harvest season; and c) that a maximum return on investment for the costs of trialing throughout the Canal Point Cultivar Development Program could be achieved by sampling the clones at a later date during the harvest season.

Floriculture: Culture Methods and Light

Moderator: Michael Maurer
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Investigating the Interactions between Blue and Far–Red Radiation in Growth of Ornamental Seedlings under Sole-source Lighting

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Blue (B, 400 to 500 nm) and far–red (FR, 700–800 nm) radiation have antagonistic effects on stem elongation; B typically suppresses extension growth while FR promotes it. Although the effects of B and FR radiation on plant growth have been investigated independently, little research has been published on how they interact to regulate extension growth and flowering. We grew seedlings of geranium (Pelargonium × hortorum), petunia (Petunia × hybrida), and coleus (Solenostemon scutellarioides) at 20 °C under six sole-source LED lighting treatments with an 18-h photoperiod. All treatments provided a photosynthetic photon flux density of 160 μmol·m⁻²·s⁻¹ with the following intensities (subscript in μmol·m⁻²·s⁻¹) of B (peak = 447 nm), red (peak = 660 nm), or/and FR radiation (peak = 731 nm): B80R80, B80R80FR10, B80R80FR80, R160, R160FR20, and R160FR160. When seedlings were sufficiently large, they were transplanted into 10-cm pots and subsequently grown in a common greenhouse finishing environment at 20 °C with a 16-hour photoperiod. As expected, stem length of all species increased linearly with additions of FR [as the R:FR or estimated phytochrome photoequilibrium (PPE) decreased]. When R was partly substituted with B light (B80R80), stem length of shade-avoiding petunia and geranium also increased linearly with decreasing PPE, but substantially less (35 to 85%) than under R160. In shade-tolerant coleus, there was little to no effect of PPE on stem elongation under B80R80. In geranium, shoot dry weight decreased linearly with increasing PPE similarly under R160 and B80R80, while in petunia, similar trends occurred only under R160. In the long-day plant petunia, decreasing the PPE promoted subsequent flowering by 7–11 d under B80R80 and R160. In day-neutral geranium, plants grown under R160FR160 flowered earlier (by 4 d) than those grown under B80R80. We conclude that a moderately high intensity of B attenuates the effects of FR radiation on extension growth but has no apparent effect on the FR-promotion of flowering promotion in at least some long-day plants.
Influence of Propagation Daily Light Integral and Root-zone Temperature on Rooting of Single-Internode *Pennisetum advena* Culm Cuttings

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Culm cuttings are an economically attractive method for propagating purple fountain grass (*Pennisetum advena* Wipff and Veldkamp (formerly known as *P. setaceum* Forsk. Chiov. ‘Rubrum’)) for quick liner production. Research objectives were to quantify the impact of propagation daily light integral (PDLI) and root-zone temperature (RZT) on rhizogenesis and culm development of single-internode purple fountain grass culm cuttings. Prior to culm cutting insertion, cuttings were treated with a basal dip rooting hormone solution containing 1000 mg·L⁻¹ indole-3-butyric acid (IBA) + 500 mg·L⁻¹ 1-naphthaleneacetic acid (NAA). Cuttings were placed in a glass-glazed greenhouse with an air temperature of 23 °C, benches with RZT set points of 21, 23, 25, or 27 °C, and under PDLIs of 4 and 10 mol·m⁻²·d⁻¹ (Expt. 1) or 8 and 16 mol·m⁻²·d⁻¹ (Expt. 2). At 28 d, greater root biomass accumulation occurred under a PDLI of 10 mol·m⁻²·d⁻¹ than 4 mol·m⁻²·d⁻¹. For example, as PDLI increased from 4 to 10 mol·m⁻²·d⁻¹, root dry mass increased by 105, 152, and 183% at RZTs of 21, 25, and 27 °C, respectively. In Expt. 2, RZT increasing from 21 to 23 °C resulted in 70% more root dry mass for cuttings under a PDLI of 8 mol·m⁻²·d⁻¹ while root dry mass was similar among all RZTs under 16 mol·m⁻²·d⁻¹. When these results are taken together, single-internode culm cuttings of purple fountain grass can be most efficiently propagated under PDLIs of 8 to 10 mol·m⁻²·d⁻¹ with RZT set points of 23 to 25 °C for quick liner production.

Enhancing Herbaceous Perennial Stock Production through the Application of Three Plant Growth Regulators

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Commercial growers throughout the Rocky Mountain Region have an increased demand for sustainable herbaceous perennial plants. Production of these adaptable perennials has resulted in problems in stock plant management and propagation. The objective of this study was to determine the efficacy of plant growth regulators applied as foliar sprays on the vegetative growth of *Heuchera sanguinea* ‘Snow Angel’ and *Zauschneria garrettii* ‘Orange Carpet’ propagation stock plants in number one containers. Three chemical plant growth regulators were applied at two different rates: 1) ethephon [250 and 500 mg·L⁻¹ (ppm)] (Verve, Nufarm Americas, Inc., Alsip, IL); 2) 6-benzylaminopurine (200 and 400 mg·L⁻¹) (Configure; Fine Agrochemicals Limited, Worcester, U.K.); and 3) gibberellins A4A7 (GA) & N-(phenylmethyl)-1H-purine 6-amine (50 and 100 mg·L⁻¹) (Fascination; Valant USA Corp., Fresno, CA). Twelve replications of the two taxa were evaluated once for four months for plant height, width, number of branches, number of cuttings, and fresh & dry weight of the cuttings. This study was replicated twice, the first experiment was performed from Nov. 2016 to Mar. 2017, and the second experiment was performed from Aug. 2017 to Dec. 2017. The two different seasons aided in indicating a better time of year for stock production of these two herbaceous perennials. *Heuchera* plants that received GA treatments at 50 and 100 mg·L⁻¹ and 6-benzylaminopurine at 400 mg·L⁻¹ concentrations resulted in 17%, 22%, and 20% more cuttings taken than control plants. All concentrations of ethephon treated *Heuchera* plants were similar to the control plants, respectively. *Zauschneria* plants that received GA treatments at 50 and 100 mg·L⁻¹ and 6-benzylaminopurine at 200 mg·L⁻¹ concentrations had 14%, 16%, and 10%, respectively. *Zauschneria* plants that received GA treatments at 50 and 100 mg·L⁻¹ had a decrease of 13% and 14% for the fresh weight of cuttings taken when compared to the control.

Successful Rooting of *Heuchera sanguinea* ‘Snow Angel’ Stem Cuttings Is Influenced By Greenhouse Temperature and Season of Propagation

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A greenhouse experiment was conducted at Colorado State University to determine the effect of stock plant container size and growth media on the rooting of vegetative cuttings from *Heuchera* ‘Snow Angel’. Although stock plant treatment had little influence on the rooting capability of cuttings, it appears that temperature and time of year may play a key role in stock plant productivity and the rooting process. Stock plants grown between 18.3 to 22.8 °C (day) and 16.1 to 22.8 °C (night) produced more cuttings per plant between October and March with 94.4 to 100% rooting success during April, May and June. Stock plants grown between July and November in a greenhouse kept between 16.7 to 20.0 °C (day) and 12.8 to 16.7 °C (night) produced fewer cuttings that were larger and cuttings rooted with 100% success during December, January and February. During the rooting process of the experiment, bottom heat was set to maintain the soil temperature at 18.3 °C (65 °F) and intermittent mist was applied to provide a humid environment. For most cuttings, roots began to form after one to two weeks and the number of visible roots exceeded 35 after 4 weeks under mist.

**Specified Source(s) of Funding:** USDA Colorado Specialty Crop Block Grant (2016), Colorado Horticulture Research and Education Foundation, Plant Select
2:45 PM – 3:00 PM

**Pinching Specialty Cut Sunflowers to Increase Production**

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Specialty cut sunflower (Helianthus annuus L.) cultivars response to pinching depends on time of planting and cultivar characteristics. Experiments evaluated five non-branching sunflower cultivars ‘Pro Cut Gold’, ‘Sunbright Supreme’, ‘Sunrich Lemon’, ‘Superior Gold’ and ‘Vincent’s Choice’ pinched at nodes 0 (non-pinched), 1, 2, 3, or 4. Stem length, stem diameter, flower diameter, and disk diameter were measured at harvest along with days-to-harvest, number of stems and number of marketable stems. Pinched sunflowers produced significantly more stems than the non-pinched sunflowers, but also resulting in decreased stem length, stem diameter, flower diameter and disk diameter. Conversely, days-to-harvest increased with pinching. Spring planting increased the number of marketable sunflower stems pinched at nodes 1, 2, and 3, but Fall planting produced a similar number of marketable stems to the non-pinched treatment. The more vigorous cultivar ‘Superior Gold’ tended to performed better than less vigorous cultivar such as ‘Sunrich Lemon’. These initial experiments indicate that pinching specialty cut sunflowers may not be an effective method for increasing sunflower production in Texas.

3:00 PM – 3:15 PM

**Effect of GA₃ Drenches and Duration of Chilling on Growth and Flowering of Containerized Peonies**

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Herbaceous peony (Paeonia lactiflora Pall.) is a popular landscape plant in temperate regions because of its great ornamental value. Peony needs a chilling period to break dormancy and enhance flowering. The objective of this study was to evaluate gibberellic acid (GA₃) effects on replacing chilling requirement and increasing the number of flowering shoots of plants held under different controlled chilling durations. Two peony cultivars, ‘Sarah Bernhardt’ and ‘Inspecteur Lavergne’, from 3–5 eye crowns from Holland, were potted in 1.7-L pots. Plants were placed in a 5 °C cooler for 6 weeks in a preliminary study, and 3, 4, or 5 weeks in a follow up study. GA₃ (Florigib, Fine Americas) was applied as a 0 or 100 mg/L drench (250 mL/pot) after moving plants from cooler to greenhouse. For the preliminary study of peonies chilled for 6 weeks, GA₃ did not shorten days to emergence (13 days for both with and without GA₃), but increased the number of shoots on both cultivars (3.7 shoots/pot without GA₃ to 4.9 shoots/pot with GA₃ in ‘Inspecteur Lavergne’, and 3.6 shoots/pot without GA₃ to 5.0 shoots/pot with GA₃ in ‘Sarah Bernhardt’) and the number of flowering shoots in ‘Inspecteur Lavergne’. For the follow up study with 3, 4 or 5 weeks of chilling, GA₃ decreased the number of days to emergence (14 days without GA₃ to 10 days with GA₃ in ‘Sarah Bernhardt’, and 19 days without GA₃ to 14 days with GA₃ in ‘Inspecteur Lavergne’) while duration of chilling had no effect, and there was no interaction between GA₃ and duration of chilling. Neither GA₃ nor chilling duration affected the number of days to bud opening. The growth and flowering data are still being collected.

3:15 PM – 3:30 PM

**Identification of Plant Growth-promoting Rhizobacteria with the Ability to Alleviate Drought Stress in Floriculture Crops**

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Michelle L. Jones
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The Ohio State University, Wooster, OH, USA

Drought stress is one of the most significant factors limiting crop quality; causing stunted growth, discolored tissue, and reduced flowering. This is particularly detrimental to floriculture crops that have a value largely dependent on aesthetics. In recent years, plant growth promoting rhizobacteria (PGPR) have emerged as a sustainable solution to alleviate abiotic stress in plants. Plant roots secrete proteins and metabolites that are utilized by PGPR, and in return, the bacteria assist in the acquisition of macro and micronutrients, production of plant growth-promoting hormones, and the reduction of stress hormones such as ethylene. Although research on PGPR has gained significant interest in recent years, much of this research has focused on agronomic crops, with little emphasis on floriculture crops. In this study, two high-throughput bioassays were developed to screen a core collection of 45 Pseudomonas strains for their potential to alleviate drought stress when applied to floriculture crop production systems. Polyethylene glycol (PEG) is a well-documented compound used in bioassays for the in vitro selection of osmotic stress tolerant bacteria. This property in bacteria is commonly correlated with the ability to alleviate drought stress in plants. A
Flower Bud Development of *Lycoris Radiata* (L’Hér.) Herb. and *L. Sprengeri* Comes Ex Baker

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University of Georgia, Athens, GA, USA  
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*Lycoris radiata* (L’Hér.) Herb. and *L. sprengeri* Comes ex Baker are bulbous plants native to China. However, *L. radiata* leaved out after bloom in fall, while *L. sprengeri* sprouted out its foliage in next spring. To better understand their flower initiation and development, we conducted anatomical study of their buds from February to August. The flower bud formation stages could be divided into flower bud differentiation (from March to May) and flower bud development (from June to July) for both species. The flower-bud differentiation could be divided into nine phases as flower bud initiation, flower primordium formation, perianth formation, formation of stamen, formation of ovary, formation of pistil, inflorescence formation, formation of pollen, and formation of flower bud. The flower bud initiation of *L. sprengeri* was from late February to early March, while *L. radiata* was in the middle or late March, about 20 days behind. Although *L. sprengeri* and *L. radiata* both had completed the process of flower bud formation in early June, *L. sprengeri* only needed one month for floral development and bloom and *L. radiata* required three months. Further studies should address why flowers of *L. sprengeri* developed much faster than that of *L. radiata*?

An asterisk (*) following a name indicates the presenting author.

**Specified Source(s) of Funding:** DC Kiplinger Floriculture Endowment and American Floral Endowment

3:30 PM – 3:45 PM

**Oral Presentations**

**S188**

**Food Insecurity**

*Moderator:* Esther E. McGinnis  
North Dakota State University, Fargo, ND, USA

1:45 PM – 2:00 PM

**Understanding the Contributions of Extension Master Gardeners to the Food Insecurity Solution**

R. Michael Maddox  
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Sheri Dorn  
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Susan DeBlieck  
Iowa State University, Ames, IA, USA  
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Michigan State University, Novi, USA  
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New Mexico State University Extension, Bernalillo, NM, USA

Extension Master Gardener (EMG) volunteers are individuals trained and coordinated by Extension employees in 49 states. They are recruited and trained specifically to increase Extension’s capacity to deliver horticulture and gardening information as well as to implement educational programming that meets local issues and needs, such as food insecurity. Community gardens are recognized as a means of increasing access to fresh food and are commonly listed as EMG projects in local and state reports. The number of pounds of produce grown annually under EMG leadership in these gardens is included as a metric in the EMG national program report. Contributions of EMG volunteers to the food security solution are not fully described by numbers alone. To understand the full meaning of these numbers and the activities that support them, the Impact Evaluation Task Force was appointed by the EMG National Committee. First-year efforts included development of evaluation tools and establishment of collection methods to set the stage for the first data collection. While it is apparent that EMG volunteers are changing local food streams, forming strategic collaborations, and making monumental efforts for addressing food insecurity, key process challenges, including decentralized EMG program management and burden of data collection, complicate the measurement of true impact. Realizing that the development of quality measures takes time, the task force team has reviewed the first round of data to improve data collection and is preparing state and local coordinators for the second data collection in late 2018.

*Specified Source(s) of Funding:* Lynn Khadiagala, of the National Institute of Food and Agriculture, U.S. Department of Agriculture, provided technical assistance.
Despite having a large and vibrant agricultural economy, ten percent of North Dakotans rely upon food pantries to alleviate hunger. Food pantries normally receive generous donations of canned and boxed goods. Donations of quality fresh fruits and vegetables are rare and especially prized. In 2016, North Dakota State University Extension Master Gardeners initiated a pilot project called Veggies for the Pantry to fight food waste and to increase access to fresh produce in the Fargo–Moorhead area. The purpose of this project was to collect surplus fruits and vegetables from home gardeners and from community gardens for delivery to local food pantries. Extension Master Gardeners staffed strategically located collection points across the metropolitan area on Monday evenings and then delivered the produce to local food pantries the following day. Produce collection points were advertised through traditional news media, social media, and by word of mouth. In 2017, the project expanded to other counties. In total, Extension Master Gardeners collected and delivered over 8,900 lbs. of produce to local food pantries.

Gardening Programs to Address Food Insecurity on Native American Reservations
Rhoda Burrows*
South Dakota State University, Rapid City, SD, USA

Gardens provide fresh healthy food for families and communities, helping alleviate the persistent food shortages of the very low-income areas of our northern plains indigenous peoples. Since the formation of the reservations, Native Americans in the Great Plains have been urged to garden, with mixed success. The culture of the tribes in the 1800’s in South Dakota was based on hunting and gathering, well-suited to the short-grass prairies with sparse and unpredictable rainfall. However, many tribal members remember reservation-era grandparents growing vegetables to feed their families, a practice that few of their children continued. Interest in growing food has increased more recently, driven by a desire to increase control over the reservation food systems, as well as health issues. South Dakota reservation counties have high rates of obesity (> 40%) and diabetes (up to 19%), partially due to the poor availability and/or high cost of healthy foods in remote areas. Numerous gardening projects on SD reservations have been sponsored by many NGOs, as well as tribal organizations and universities. Many are discontinued after a few years because of changes in personnel, funding, or organizational focus. Those that persist usually have dedicated, paid gardeners. A few families have developed private large gardens providing vegetables for extended family and friends, and sometimes for sale. South Dakota State University Extension offers gardening education to support these efforts. We have tried a number of approaches over the years. Because of the widely scattered population and the transportation challenges (poor roads and often unreliable vehicles), as well as competing demands of an extended family cultural base, it can be difficult for participants to attend a series of meetings. Therefore, we’ve evolved a more flexible approach of creating demonstration gardens, a series of workshops offered at different times/places for those who are “scaling up” from personal to larger-scale production, and cooking/preserving classes. This year, we will work with private and public partners to place high tunnels and root cellars at strategically selected sites, and provide training on growing food in high tunnels. Our methods must be applicable for very low resource growers, who may live hours away from the nearest hardware store, so local low-cost or free materials are used when possible. Projects are vetted by tribal members for cultural appropriateness and programs are designed in concert with tribal members to address needs that they have identified.

Feeding the Need through Community
Christine H. Coker
Mississippi State University Coastal Research and Extension Center, Biloxi, MS, USA
Ronald Stephenson*
Mississippi State University, Bay St. Louis, MS, USA
Gary Bachman
Mississippi State University Coastal Research and Extension Center, Biloxi, MS, USA
Scott A. Langlois
Mississippi State University Coastal Research and Extension Center, Poplarville, MS, USA

Community gardens have historically addressed educational, economic, environmental, and health needs within their communities, leading to financial benefits as well as increases to food security. In the United States, community gardens were initially promoted in urban centers to provide skill training to youth and the unemployed. Today community gardeners are focused on alleviating food insecurity and building a sense of cohesion in their neighborhoods. Mississippi consistently rates high among states where food insecurity is greatest. In coastal Mississippi, there are several proactive projects addressing the issue. The People’s Garden program was initiated by the USDA to unite neighbors in a common effort and inspire locally led solutions to challenges facing our country - from hunger to climate change. This program is made up of a network of school community gardens across the United States. Cooperative efforts between the Harrison Co. Soil and Water Conservation District, Mississippi State University, and NRCS have supported several projects in Harrison County, MS. Additionally, in order to provide additional support for food security as well as educational programs directed at youth and adults, community garden and education projects were initiated in Hancock County, MS. These programs consist of two community gardens located within the

An asterisk (*) following a name indicates the presenting author.
Bay St. Louis and Waveland, MS communities as well as home gardening educational programs associated with the community in Lakeshore, MS. The primary community garden site in Bay St. Louis is focused on the production of fresh vegetables and fruits for donation to food pantries and community centers. Current amount of donations are approximately 275 kg of vegetables and fruit per season. The garden also serves as a demonstration garden to instruct community members in all aspect of home food production. In partnership with the Hancock County Youth Drug Court, educational programs directed toward at-risk youth were developed and a second community garden was created specifically targeted inclusion of these youth. Programs in financial management and nutrition were linked to garden activities. Lastly, in cooperation with church groups located in Lakeshore, MS, an area severely impacted by Hurricane Katrina, education programs were conducted addressing food insecurity through home production of fruits and vegetables. These programs focus on home production of high value produce.

2:45 PM – 3:00 PM

Enabling Accessibility and Success to Address Food Insecurity

Gary R. Bachman
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Food insecurity is a real problem all across Mississippi and the interest in local/home grown food is increasing. Mississippi State University personnel have been promoting a couple of growing strategies to address these needs, especially focusing on garden accessibility. EarthBoxes are a sub-irrigated growing system that has been used with great success by new gardeners growing their first garden to Master Gardeners. They are easily placed on tables, stands and benches to effectively raise the level of the garden to those with accessibility problems. Homeowner John Monroe is making a difference in his garden which contains 128 EarthBoxes, all of which are on raised benches. He has relied on MSU Extension for ideas and advice to help him grow various produce throughout the year according to season. Each year about 95% is donated to the local community, especially the elderly to which gardening has become too hard. Looking for a way to enable individuals with disabilities that may not allow them to participate in ‘traditional’ gardening, the Pine Belt Master Gardeners developed a raised shallow table that would allow gardeners with limited mobility to enjoy gardening from a wheelchair or walker. Five years and over 700 raised ‘salad tables’ later, these master gardeners continue to supply tables, at a small fee, to garden enthusiasts across South Mississippi. Money earned through these sales allows the Pine Belt Master Gardeners to donate a large percentage of the tables they construct to veteran groups, hospitals, universities, public schools, and scout troops. These salad tables have been used for vegetable and ornamental demonstrations at multiple Mississippi State University research locations across the state with excellent results. In addition to the accessibility quality these tables possess, anecdotal evidence from hundreds of users suggest that they may offer benefits which include reduced pest and weed pressure facilitated by the raised design. Recent modifications, based on user feedback, include options for varying leg heights (supporting specific needs of handicapped users), trellis supports for taller vegetable varieties and deeper tables allowing production of root crops and larger crops benefiting from an increased depth of soil.

3:00 PM – 3:15 PM

Developing a Local Foods Program

Pamela Bennett*
Ohio State University Extension, Springfield, OH, USA

Clark County Ohio is predominantly rural with less than 1% of the county’s 400 square miles consisting of urban areas and a population of 138,333. The largest city is Springfield with a population of 60,608. Larger urban communities in Ohio had been addressing the local foods issue for approximately four years prior to this with many of them having food councils already in existence. Rural communities were just beginning to look at this issue. Ohio State University had a Local Foods Signature Program that provided assistance in developing these programs. With the growing interest in Clark County, the Extension Educator provided leadership in developing a comprehensive local foods program for this rural community beginning in 2015. Essential components of a local foods program for the county were identified by a steering committee consisting of Extension professionals, Extension Master Gardener Volunteers and community stakeholders. These components included organizing a local food council, public education on the concept of local foods and insecurity, a commercial kitchen that could be used as an incubator for new food-based startups, and a framework for food-based economic development opportunities. Extension provided leadership for the steering committee and the overall program development by obtaining funding for a part-time staff member. The steering committee established goals and objectives that included a implementing a yearly Food Summit, the development of a local foods council and a commercial kitchen, and bringing stakeholders together to develop a site for a year round farmer’s market. This session discusses the challenges in developing a local foods program as well as the successes that assist the county in addressing food insecurity. The Food Council has been organized and is in its strategic planning phase; community stakeholders have plans and the financing to create a commercial kitchen; an historic building has been identified as a location for a year round market.

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Oral Presentations

Plant Biotechnology 2

Moderator: Changhyeon Kim
North Dakota State University, Fargo, ND, USA

2:00 PM – 2:15 PM

Optimization of Malus ‘Spring Sensation’ Floral Aroma Determination Using Electronic Nose
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Floral aroma plays an important role in the reproductive processes of plants and the aesthetic implication of ornamental plants. Accurate determination of aroma components is limited by collection and analysis methods. Electronic nose (E-nose) can recognize single or complex odor quickly and completely and has been widely applied for food science. We analyzed floral aroma of Malus ‘Spring Sensation’ using Pen3 E-nose with the orthogonal design at various flowering stages, sample quantity, collecting time, headspace equilibrium temperature and duration. The results indicated that the impact of various factors on the sensors of E-nose was: collecting time > headspace equilibrium temperature > flowering stage > sample quantity > equilibration duration. The most important factor was collecting time and equilibrium duration had the less impact on the electronic nose. The optimal condition was A,B,C,D,E, which meant flowers in bloom (A), 4 g of flowers (B) collected during 10:00–12:00 am (C) and the flower sample could be analyzed after equilibrating at 20 °C (D) for one hour (E). The sensor #7 and #9 of the E-nose had higher peak during the analysis processes of crabapple floral aroma, but the sensor #1, #3, and #4 had very lower detection. Our findings suggested that the sensor array should be optimized before handling the data of floral aroma. The E-nose could be applied for quick determination of Malus ‘Spring Sensation’ floral aroma, which could be further applied to distinguish crabapple taxa.

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2:15 PM – 2:30 PM

Genome-wide Association Study and Genomic Selection for White Rust in Spinach
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White rust, caused by Albugo occidentalis, is a severe disease of economic importance that causes reduction in yield and quality in spinach (Spinacia oleracea L.). Because no major genes have been reported for resistance to white rust, quantitative resistance has been employed to manage white rust. Selecting for quantitative traits using classical breeding methods can be a challenge. However, the use of molecular markers linked to qualitative traits can be valuable. The objectives of this study are to evaluate and screen white rust resistance in a collection of world-wide spinach germplasm, to conduct genome-wide association study (GWAS) and identify SNP markers, and to do genomic selection (GS) for white rust resistance in spinach. A total of 910 spinach genotypes were evaluated in four seasons (the winter of 2014–15, 2015–16, 2016–17, and 2017–18) at the Del Monte White Rust Nursery in Crystal City, TX. Over 100 spinach genotypes have been identified with levels of quantitative resistance to white rust pathogen. SNPs identified from genotyping by sequencing (GBS) were used as genotypic data. Thus far, GWAS was conducted in 412 spinach genotypes using 648 SNPs and performed with compressed mixed linear model (cMLM) implemented in the GAPIT R package. Eight SNP markers were identified that were strongly associated with white rust resistance. Genomic estimated breeding values (GEBVs) were calculated using the best linear unbiased estimator (BLUE) plus best linear unbiased prediction (BLUP) in GAPIT with both genome-wide SNP set (648 SNPs) and the only associated SNP markers (8 SNPs). The GS was validated in the association panel with 250 spinach genotypes as s training set and 162 genotypes as validation set with high correlation coefficients (r) between the predicted breeding value and the phenotypic white rust resistant data: r = 0.66 and 0.68 with 648
SNP set and 8 SNP set, respectively. The data from this study will provide breeders with a set of markers to select for white rust resistance in spinach breeding programs through marker-assisted selection (MAS) and GS.

2:30 PM – 2:45 PM

**Agrobacterium-mediated Transformation of Raspberry Species (Rubus spp.)**

Changhyeon Kim*
North Dakota State University, Fargo, ND, USA

Wenhao Dai
North Dakota State University, Fargo, ND, USA

Raspberries (*Rubus spp.*) are a group of high-value woody species and their fruits are available in a variety of forms in grocery products. Due to the complicated genetic background and perennial nature, improvement of raspberry species, such as yield and fruit quality using conventional breeding is time-consuming. Plant biotechnology including genetic transformation can not only develop novel breeding materials, but also help speed up the breeding process. In this research, one purple raspberry (*R. occidentalis* × *R. idaeus*) ‘Amethyst’ and two red raspberry cultivars (*R. idaeus*) ‘Polana’ and ‘Joan J’ were used to develop an efficient genetic transformation system for raspberry species. *Agrobacterium tumefaciens* strain EHA105 harboring pBI121 or pCAMBIA S1300 with the selection gene *nptII* or *hpt* and the target gene *PtFIT* in response to iron deficiency in *Populus*. Young in vitro leaves and petioles (7-day-old) were infected by submerging in the bacterial solution for 10 min and then co-cultivated for 3–5 days. Transgenic cells were recovered and shoots were regenerated in the media with various concentrations of kanamycin or hygromycin. Transformation was confirmed using polymerase chain reaction (PCR). Expression of the *PtFIT* gene is being determined using real-time quantitative PCR. The genetic transformation system can be used for gene functional analysis and germplasm enhancement in raspberry or related species.

**Oral Presentations**

**Pomology 3**

**Moderator:** Travis Robert Alexander
Washington State University, NWREC, Mount Vernon, WA, USA

2:00 PM – 2:15 PM

**Foliar Application of Plant Hormones and Nitrogen Have Differential Effects on Sweet Cherry Spur Leaf Development**

Feiran Li*
Michigan State University, East Lansing, MI, USA

In spring, sweet cherry bloom, fruit set, and spur leaf development are dependent on storage carbohydrates. Subsequent fruit and new shoot development relies on photoassimilates supplied by new spur, and eventually shoot, leaves. Thus, horticultural techniques that increase spur leaf size would be expected to increase the carbohydrate supply capacity for the remainder of fruit development. Leaf photosynthetic capacity is determined by physical features, such as specific leaf area (the ratio of leaf area to leaf dry mass) and stomata density, and biochemical features (particularly nitrogen content per unit area). This study examined post-bud break foliar applications of cytokinin (6-benzylaminopurine, 6-BA), gibberellin (GA₃, the combination 6-BA plus GA₄+7, and several nitrogen fertilizers to improve spur leaf size. Foliar applications were made to individual spurs of ‘Sam’ sweet cherry trees before sunrise by hand-held trigger-pump sprayer as follows: T1: 0.5% urea; T2: 150 ppm 6-BA; T3: 30 ppm GA₃; T4: distilled water (control); T5: 2.0% Ca(NO₃)₂; T6: 1.7% KNO₃; and T7: 150 ppm 6-BA plus 30 ppm GA₄+7. Applications were made when the first spur leaf was large enough to measure, usually between full-bloom and the petal fall, with five replications. For each spur leaf, length and width was measured every ~60 growing degree days (GDD, base 7.2 °C) from emergence to complete expansion. Small sections were cut from leaf margins to determine cell number and size. Statistical comparisons (Wilcoxon, 0.05) showed that all of the phytohormone treatments significantly increased final leaf area, while none of the nitrogen treatments differed from the control. Ca(NO₃)₂ (T5) caused young leaf marginal burning and cupping and was omitted from further data collection. To simplify the leaf growth curve analyses (173 curves total), mean growth curves were ranked for the five largest leaves for each spur and grouped by the largest to the smallest final leaf area. These mean growth curves revealed 6-BA plus GA₄+7 (T7) increased overall spur leaf area by ~50%, and 6-BA (T2) and GA₃ (T3) increased overall spur leaf area by ~20%. Analysis of leaf cell number and size was highly variable, but treatments that increased spur leaf area appeared to largely increase cell elongation. The results are promising for developing horticultural treatments to increase spur leaf area in spring, though further research on timings and rates is needed.

2:15 PM – 2:30 PM

**Comparison of the Polyphenol Profiles of Juice and Cider Derived from Machine- and Hand-harvested ‘Brown Snout’ Specialty Cider Apple in Northwest Washington**

Travis Robert Alexander*
Washington State University, NWREC, Mount Vernon, WA, USA

Tom Collins
Washington State University, Wine Science Center, Richland, WA, USA

Carol Miles
Washington State University, NWREC, Mount Vernon, WA, USA

In this study, the polyphenol profiles of juice and cider derived from over-the-row machine- and hand-harvested ‘Brown Snout’ that were ambient stored (56 °F) 0–4 weeks postharvest were compared utilizing analytical chemistry. Variation due to harvest method was found to be non-significant (P > 0.05) for all quality characteristics [specific gravity (SG), pH, titratable acidity (TA), and tannin content] measured on juice and cider samples.

An asterisk (*) following a name indicates the presenting author.
Oral Presentations

The SG, pH, and TA of juice samples significantly differed due to duration of ambient storage ($P = 0.01$, $P = 0.04$, and $P = 0.01$), fruit likely underwent dehydration over time. The SG, pH, and TA of cider samples did not significantly differ due to duration of storage ($0.999 \pm 0.000$, $3.52 \pm 0.01$, $0.63\% \pm 0.02\%$), which was expected as these three parameters were artificially adjusted for controlled fermentation. The tannin content of juice and cider samples did not differ due to harvest method or duration of storage ($0.19\% \pm 0.01\%$). The ABV of cider samples differed due to duration of storage ($P=0.02$). Fruit that was pressed immediately after harvest (0 weeks storage) on average had ABV of $5.39\% \pm 0.19\%$, whereas fruit that was stored under ambient conditions for 4 weeks had on average $6.14\% \pm 0.16\%$ ABV; a higher sugar content in the stored fruit allowed for greater alcohol production by yeast. Total phenolics and total tannins [measured in catechin equivalents (CE)] of juice and cider samples did not significantly differ due to duration of ambient storage time. Total phenolics of juice samples did not significantly differ due to harvest method ($1415 \pm 98$ mg·L$^{-1}$ CE). Total tannins of juice samples did significantly differ due to harvest method ($P < 0.0001$). Machine-harvested juice samples had lower levels ($231 \pm 36$ mg·L$^{-1}$ CE) of total tannins than hand-harvested juice samples ($420 \pm 14$ mg·L$^{-1}$ CE). Total phenolics and total tannins of cider samples did not significantly differ due to harvest method ($1431 \pm 73$ mg·L$^{-1}$ CE and $203 \pm 22$ mg·L$^{-1}$ CE). The harvest cost savings provided by over-the-row machine-harvesting of ‘Brown Snout’ appears to come at the cost of lower polyphenol content in the final cider product. Modification of pressing methodology to maximize extraction of phenolic compounds from machine-harvested fruit or the addition of exogenous phenolic compounds to collected juice could serve to minimize the observed reduction in cider polyphenol content.

Specified Source(s) of Funding: Washington State University Emerging Research Issues Grant, the Washington State Department of Agriculture Specialty Block Grant Project No. K1270, the Northwest Agricultural Research Foundation, and State project WN00427 – Acc. # 1000194

2:30 PM – 2:45 PM

The Effect of Fruit Removal and Rootstock on Stored Carbohydrates and Response to Chemical Thinning in Apple

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Total non-structural carbohydrate (TNC) availability in apple trees (Malus domestica Borkh.) is affected by light availability, temperature and other environmental factors as well as physiological processes such as respiration, tree growth, and crop load. These factors affect photosynthesis and starch accumulation (energy supply) and alter energy requirements for tree growth (demand). The balance between carbohydrate supply and demand is particularly important for apple development at thinning time when fruitlets are 10–12 mm in diameter and competition for carbohydrates is high. If current season carbohydrate supply to competing fruitlets is low, the application of chemical thinners may be more effective resulting in a lower crop density than if carbohydrate availability is high. However, if starch concentrations, accumulated in the previous year are high, more carbohydrates may be available for fruitlets which may limit the effect of a chemical thinner application and result in a higher crop density. ‘Golden Delicious’ trees on M.9, M.26, and G.16 rootstocks were used to investigate the effect of fruit removal treatments at 29, 125, 154, and 182 days after full bloom (DAFB) in 2013 on glucose and starch concentrations in current-season shoots and 1- and 2-year-old branch sections the following season. The effect of fruit removal on thinning efficacy the following year was also investigated and trees were sprayed with water (control) or a mixture of 0.95 L Carbaryl 4 L and 5 ppm of NAA (Fruitone N) in 378.5 L of water. We hypothesized that trees with fruit removal treatments at 29 and 125 DAFB would have higher glucose and starch concentrations and higher crop density after thinner application the following year while trees with fruit removal at 154 and 182 DAFB would have lower glucose and starch concentrations and lower crop density after thinner application. Trees with fruit removal at 29 DAFB had greater return bloom than trees with fruit removal later in the season. Fruit removal and application of chemical thinner enhanced available glucose and starch concentrations (mg·g$^{-1}$ dry weight) in actively growing shoots and 1- and 2-year-old wood; however, this depended on time of year and rootstock.

Specified Source(s) of Funding: State Horticultural Association of Pennsylvania

2:45 PM – 3:00 PM

Estimation of a Crop Coefficient for Low-Chill Peach Trees in Subtropical Humid Climates

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Oral Presentations

HortScience 53(9) Supplement—2018 ASHS Annual Conference

Florida’s agricultural industry is moving to non-traditional crops such as peaches, which are common crops in northern latitudes. Low-chill peach cultivars allow Florida growers to market their crops before northern states, thereby obtaining premium prices. Irrigation is a common practice for peach production in Florida and is required to maximize yields. Current irrigation recommendations and peach crop coefficients were determined in arid climates which likely are inaccurate for humid climates. The objectives of this study were to estimate the daily crop evapotranspiration (ETc) and the crop coefficient (Kc) of adult peach trees. Three trees were evaluated during 18 months in north-Florida for water uptake. Soil moisture sensors measured daily changes in soil volumetric water content every 10 minutes to calculate a daily water balance and estimate ETC. Daily values of reference evapotranspiration (ETO) were used to estimate Kc. Daily ETC ranged from 0.71 mm·d⁻¹ during dormancy, 3.39 mm·d⁻¹ during fruit development and 2.47 mm·d⁻¹ during vegetative growth. Daily estimated Kc ranged from 0.64 during dormancy, 0.8 during fruit development and 0.6 during vegetative growth. Daily peach Kc estimations provide a more accurate guideline to peach growers for irrigation practices in humid climates, compared with previous recommendations.

Specified Source(s) of Funding: FDACS

3:00 PM – 3:15 PM

Characteristics of 180 Hard Cider Apple Genotypes in the USDA-PGRU Malus Germplasm Collection

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In the United States, hard cider producers are increasingly interested in acquiring apple genotypes (Malus ×domestica Borkh. and other Malus species) that possess higher concentrations of tannins (polyphenols that taste bitter and/or astringent) and acidity (described as having a sharp taste) than what is typically found in culinary apples. The purpose of this research project was to phenotype a targeted population of genotypes in the United States Department of Agriculture-Plant Genetic Resources Unit (USDA-PGRU) Malus germplasm collection in Geneva, NY, for desirable cider apple characteristics. Through a literature search for apples that were historically used in cider production and by the data-mining of the USDA Germplasm Resources Information Network Global (GRIN Global) database, we identified 308 potential candidates of which 180 were characterized in 2017. In the PGRU, each genotype is physically represented by a single-tree accession. Fruit weight (133; 13.4–599 g), diameter (65.6; 31.3–123.3 mm) red peel percent (49.9; 0 to 100%) or yellow-green background color (2.49; 1–4), flesh firmness (64; 4.5–140 N), peel chlorophyll-a (1.04; 0–2.1), and cortex starch pattern index, a 1–8 scale based on potassium iodine staining, (7.73; 3–8) was measured on three 15-apple subsamples from each accession (mean; range of measured values from the sample population is shown in parenthesis). Apple juice was evaluated for: soluble solid concentration (12.3; 2.8–21.5 °Brix), titratable acidity (4.84; 0.26–22.9 g·L⁻¹); and polyphenol concentration (1.31; 0.092–5.14 g·L⁻¹) (as measured by the Folin-Ciocalteu assay). Sucrose (32.3; 0–107 g·L⁻¹), glucose (21.0; 3.8–74.4 g·L⁻¹), fructose (63.1; 11.5–123.0 g·L⁻¹) and sorbitol (10.4; 0.288–39.0 g·L⁻¹) have also been measured on a subset of apple juice samples. As per the Long Ashton Research Station cider apple classification system (>0.2% (w/v) tannins bitter; >0.45% (w/v) malic acid is sharp), 29% of the 180 accessions would be classified as bittersweet, 13% as bittersharp, 28% as sweet (neither bitter nor sharp), and 30% as sharp (Folin–Ciocalteu values were corrected to accurately reflect the Lowenthal Permanganate Titration assay). These results confirm observations that apples with high polyphenol concentration, particularly those classified as bittersharp, are less common in the germplasm than sweet or sharp apples. Through this research, we hope to identify accessions within the USDA Malus germplasm collection that are of interest to the emerging hard cider industry. Future work will determine the seasonal variability in fruit and juice characteristics, as well as other important features, such as precocity, bearing habit, disease resistance, and overall compatibility with high-density apple orchard systems.

Specified Source(s) of Funding: USDA Hatch, United States Association of Cider Makers (USACM), Cornell-SIPS-Horticulture

3:15 PM – 3:30 PM

Physiological Responses and Nutrient Uptake for ‘Gala’ and ‘Honeycrisp’ Apples Grafted on G41, M9-337, B9, and G890 Rootstocks

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Lee Kalcisits
Washington State University, Wenatchee, WA, USA

‘Honeycrisp’ and ‘Gala’ apple cultivars are two of the most commonly planted cultivars in Washington State. However, ‘Honeycrisp’ is susceptible to several nutrient-related physiological disorders and Gala is less susceptible. Rootstocks can affect scion growth and nutrient balance and are strongly influenced by the soil environment. Washington State can experience periodic water limitations and elevated soil temperatures. Still, the contribution of rootstocks including rootstock-scion interactions regulating plant responses to soil abiotic stress are poorly understood. The objective of this study was to evaluate the response of potted ‘Gala’ and ‘Honeycrisp’ apple trees grafted to four different rootstocks (G41, M9-337, B9, and G890) to soil abiotic stress (drought and heat). At the Washington State University Tree Fruit Research and Extension Center, 72 trees (9 of each rootstock-scion combination) were grown in a

An asterisk (*) following a name indicates the presenting author.
The concentration of 20 individual amino acids in apple juice in two ways: one looking at the development of amino acid concentrations throughout the growing season and one looking at this development in response to foliar fertilization. In the 2016 and 2017 seasons we applied weekly urea foliar sprays (5.1 g N/L solution) to Crimson Crisp® apple trees on M9 rootstock weekly after petal fall at three treatment levels: zero sprays, three sprays, and six sprays. The orchard was divided into eighteen units of ten trees. Each treatment was applied to six units in the orchard in a completely randomized design. Sprays began 7 days after full bloom ended. After the third spray was completed and every three weeks thereafter until maturity apples were collected from each unit and processed into juice. The juice was then analyzed for amino acid concentrations using high performance liquid chromatography. The results indicate that the greatest changes in amino acids within the growing season are the overall reduction in FAN concentration, the decline of asparagine concentration, and the increase in aspartic acid concentration as the fruit approaches maturity. The study found that the six-spray treatment increased the concentration of FAN in juice, but FAN concentrations in juices from the zero- and three-spray treatments were not significantly different from one another. The most notable differences in the amino acid concentrations in mature fruit were higher concentrations of aspartic acid, asparagine, methionine, and valine in the units that received six sprays. This information can be used by cider producers to better plan for their supplementation regimens during fermentation. Further research is required to investigate other forms of nitrogen fertilization as well as the effect of spray timing.

**Specified Source(s) of Funding:** University of Guelph, Growing Forward 2 Program, the Ontario Ministry of Agriculture, Food, and Rural Affairs, the Ontario Craft Cider Association, and the Norfolk Fruit Growers' Association

3:45 PM – 4:00 PM

**Development and Validation of a Pollen Tube Growth Model for Precise Thinning of Apple ‘Red Delicious’ Blossoms**

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Keith Yoder
Virginia Tech, Winchester, VA, USA

The profitability of apple fruit producers is largely dependent upon consistent, high annual yield of quality fruit. In commercial apple production systems, this cannot be achieved without effective crop load management strategies that make a balance between vegetative and fruiting buds, reduce fruit-to-fruit competition, allow fruit enough room to grow, expose fruit to adequate sunlight and enhance return bloom. Winter pruning of dormant trees, chemical thinning of blossoms and fruitlets and hand thinning of fruit are the three common crop load management strategies. Chemical thinning can start at bloom stage and continue until fruits reach 25 mm in diameter. It is already well-established that crop thinning during bloom produces the largest fruit, the
The majority of the responding MGs are female (154; 87.20%), with the organization. We distributed a survey via Qualtrics to Master Gardeners are a critical resource for Delaware (DE) Extension, and we conducted a survey in Winter 2017 to measure their demographics, perception of initial training, attribution of skills to learning experiences (initial training, advanced training, and volunteer experience), volunteer satisfaction, connection with sponsoring organizations (DE Extension, DE State University, and University of DE), and intent to remain with the organization. We distributed a survey via Qualtrics (Qualtrics, LLC, Provo, UT) to 282 current, active DE Master Gardeners, receiving 198 responses for a 70.2% response rate. The majority of the responding MGs are female (154; 87.20%), white (183; 91.92%), and college-educated (136; 70.10%), and the mean age is 70.45 years old. While not representative of the general population, these demographics are similar to those of other MG programs (Jeannette and Meyer, 2002; Schrock et al., 2000a). Delaware Master Gardeners had an average of ten years of service, gardened an average of four times per week, and participated in an average of seven volunteer activities. Master Gardener Volunteers highly rated their overall training experience (M = 6.31, SD = 0.99; scale of 1 to 7), and they felt general knowledge could be attributed most significantly to original training, whereas the confidence to teach practices and find answers to questions could be attributed most significantly to advanced training and volunteer experience. As measured by the Volunteer Satisfaction Index (VSI) (Galindo-Kuhn and Guzley, 2001), Master Gardeners highly rated their overall program satisfaction (M = 6.00, SD = 0.92; scale of 1 to 7), with empowerment as the highest sub-category (M = 6.18, SD = 0.95) and participation efficacy (volunteer’s perception of their ability affect change with their volunteer work) as the lowest sub-category (M = 5.83, SD = 0.91). Regardless of home county, Master Gardeners felt significantly stronger connections to DE Extension than either academic institution, University of DE, or DE State University. Finally, Master Gardeners reported that they intend to remain with the program, for the next year (M = 6.44, SD = 1.24; scale of 1 to 7), and for three years (M = 5.91, SD = 1.63). Overall, these data suggest DE Master Gardeners are satisfied with their work and learning opportunities. However, there are several areas for improvement. Long term goals include diversification of the volunteers to better match the constituent population (Bobbitt, 1997) and increasing volunteers connections to the sponsoring academic institutions at which they can find valuable resources. More attainable in the short term, volunteers need to see the impact of their own and others’ volunteer work such that they can build participation efficacy, increasing their sense of ability to affect change.

Specified Source(s) of Funding: Washington Tree Fruit Research Commission

Consumer Horticulture and Master Gardeners

Moderator: Ellen Bauske
University of Georgia, Griffin, GA, USA

3:15 PM – 3:30 PM

Delaware Master Gardeners: A Report on Volunteer Satisfaction, Perception of Training and Retention Intent

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Susan Barton
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Master Gardeners are a critical resource for Delaware (DE) Extension, and we conducted a survey in Winter 2017 to measure their demographics, perception of initial training, attribution of skills to learning experiences (initial training, advanced training, and volunteer experience), volunteer satisfaction, connection with sponsoring organizations (DE Extension, DE State University, and University of DE), and intent to remain with the organization. We distributed a survey via Qualtrics (Qualtrics, LLC, Provo, UT) to 282 current, active DE Master Gardeners, receiving 198 responses for a 70.2% response rate. The majority of the responding MGs are female (154; 87.20%), white (183; 91.92%), and college-educated (136; 70.10%), and the mean age is 70.45 years old. While not representative of the general population, these demographics are similar to those of other MG programs (Jeannette and Meyer, 2002; Schrock et al., 2000a). Delaware Master Gardeners had an average of ten years of service, gardened an average of four times per week, and participated in an average of seven volunteer activities. Master Gardener Volunteers highly rated their overall training experience (M = 6.31, SD = 0.99; scale of 1 to 7), and they felt general knowledge could be attributed most significantly to original training, whereas the confidence to teach practices and find answers to questions could be attributed most significantly to advanced training and volunteer experience. As measured by the Volunteer Satisfaction Index (VSI) (Galindo-Kuhn and Guzley, 2001), Master Gardeners highly rated their overall program satisfaction (M = 6.00, SD = 0.92; scale of 1 to 7), with empowerment as the highest sub-category (M = 6.18, SD = 0.95) and participation efficacy (volunteer’s perception of their ability affect change with their volunteer work) as the lowest sub-category (M = 5.83, SD = 0.91). Regardless of home county, Master Gardeners felt significantly stronger connections to DE Extension than either academic institution, University of DE, or DE State University. Finally, Master Gardeners reported that they intend to remain with the program, for the next year (M = 6.44, SD = 1.24; scale of 1 to 7), and for three years (M = 5.91, SD = 1.63). Overall, these data suggest DE Master Gardeners are satisfied with their work and learning opportunities. However, there are several areas for improvement. Long term goals include diversification of the volunteers to better match the constituent population (Bobbitt, 1997) and increasing volunteers connections to the sponsoring academic institutions at which they can find valuable resources. More attainable in the short term, volunteers need to see the impact of their own and others’ volunteer work such that they can build participation efficacy, increasing their sense of ability to affect change.

Specified Source(s) of Funding: Delaware Cooperative Extension

3:30 PM – 3:45 PM

The Impact of Remote Training on Program Satisfaction and Retention Intent of Delaware Master Gardeners

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Susan Barton
University of Delaware, Newark, DE, USA

In 2015, Delaware Extension piloted Master Gardener remote delivery of training sessions via synchronous Zoom sessions. We evaluated trainees’ ability to apply information after sessions and perception of the training in terms of approximating an in-person experience (Barton et al. 2016). While overall quality of information application was equivalent between in-person and remote sessions, several specific sessions with technical difficulties showed reduced application ability for remote trainees and trainees perceived the remote component poorly. Despite the trend toward no significant difference in knowledge when
A Characterization of Urban Agriculture in Kentucky

Leigh Whittinghill*

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Food insecurity and economic difficulties cause some people to turn to urban agriculture to supplement the household food supply or income. Others turn to urban agriculture as part of the local food movement and for community building. There are, however, barriers to urban agriculture that impact its form and growth. Both the motivations for participating in urban agriculture and the barriers to urban agriculture can result in a wide diversity of practices used. A survey was conducted to collect information on urban agriculture in central Kentucky. Survey questions included sections on farm/garden description, farming/gardening practices, and farmer/gardener demographics. Farm description data can include information about the farm itself, such as location, number of employees, goals, what growing strategies are used, such as permaculture or season extension, and soil testing. The farming practices section includes questions on crop selection, including both plants and livestock, nutrient management practices, irrigation systems, pest and disease management, and the tools and implements used on the farm. Phase one data were gathered through in-person interviews. Phase two data collection included both in person interviews and a web based survey. Both phases of the survey were reviewed and approved by the Institutional Review Board (IRB). Data were analyzed in the Atlanta Metropolitan area. The landscapes represented a range of summer and winter shade, ability to retain water on the property, and pollinator habitats. A 1.5-hour workshop was held at which 11 Extension Master Gardeners (EMG) volunteers were trained to use the checklist. Two researchers and the EMG volunteers evaluated the houses in Aug. 2017. Participants were also asked to rank the curb appeal of each house on a scale of 0 (no appeal) to 10 (maximum appeal). Spearman Correlation Coefficients were calculated among participants for each variable, allowing for easy identification of individuals who needed additional training and variables with inconsistent evaluations. Volunteers appeared to have little difficulty assessing the level of shade provided by trees, the slope of the property, the nature of the vegetative coverage (e.g. turfgrass, herbaceous, woody ornamentals), the presence or absence of impervious surfaces, or the size and number of trees. Volunteers found it challenging to identify splash and rill erosion and to estimate the quantity of flowers on the property. This suggests the need for additional training on the corresponding aspects of the check list. Interestingly, shrubs and morning shade had significant negative correlations with curb appeal, but many other characteristics that either support or hinder sustainability (as defined above) had significant, expected positive or negative correlation. These results indicate that this methodology could be used to quickly and inexpensively assess the combined environmental impact of residential landscapes in systematic studies of large scale.
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Ornamental Plant Breeding 2

Moderator: Lisa Alexander
USDA-ARS, McMinnville, TN, USA

3:15 PM – 3:30 PM

Breeding and Genetic Research in Cut-Flower Gerberas
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Gerberas have become one of the top five most important cut flowers in the global floricultural trade. In 2010, as many as 938 million stems of cut gerbera flowers were sold at the Dutch auctions, generating 140 million euros a year. The annual wholesale values of cut-flower gerberas in the United States over the last several years have been between $32 million and $36 million. Commercial production of cut-flower gerberas also occurs in dozens of other countries. Gerbera breeding over the last 50 years has resulted in the development of numerous clonal cultivars with improved flower quality, increased flower yields, and extended vase life. A number of characteristics, including double, full-crested, and spider flowers, dark centers, and bi-coloration are now widely available in many gerbera cultivars. In recent years, Botrytis resistance, leafy stems, and twisted petals have been discovered in gerbera. Genetic, genomic and molecular studies over the last 20 years have led to the development of a number of new tools and resources for gerbera breeding, including molecular markers for Botrytis resistance, genetic linkage maps for local regions and the whole genome, candidate genes for flower types and disease resistance, cloned resident genes for anthocyanin synthesis and regulation, genomic and transcriptome sequences, and gene transfer technologies. It is expected that some of these new traits will be incorporated into new gerbera cultivars and new breeding tools will be adopted in cut-flower gerbera breeding.

3:30 PM – 3:45 PM

Segregation of Floral Traits in Althea (Hibiscus syriacus L.)
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Althea (Hibiscus syriacus) is an ornamental shrub prized for its winter hardiness and large, colorful flowers. Altheas are primarily tetraploids (2n = 4x = 80), although breeders have developed hexaploid and octoploid cytotypes. Although floral traits are most important for breeders of althea, little is known about their segregation patterns. The objectives of this study were to determine segregation patterns in eyespot presence, flower color, and flower form. Over four years, thousands of flowering seedlings were observed representing F1, F2, and backcross families. Based on our results, we propose that eyespot presence is controlled by a single locus and that a recessive allele called spotless results in a complete elimination of color. The gene controlling spotless is likely located upstream in the flavonoid biosynthetic pathway. We also propose that flowers with white to blush-pink petal body color and a red eyespot are controlled by a single recessive allele called geisha. This trait exhibits incomplete dominance and is under epistatic control by spotless. It is likely located downstream in the delphinidin biosynthetic pathway, responsible for lavender, dark pink, and blue pigments. In addition to color segregation, depth of color irrespective of hue (CIE L*) was also investigated (spotless and geisha seedlings removed). The deepest pigments were measured in crosses among hexaploid ‘Pink Giant’, taxa homozygous dominant for geisha, and taxa heterozygous for geisha. Conversely, the lightest pigments were observed in crosses between taxa homozygous recessive for geisha and taxa heterozygous for geisha. Future efforts at eliminating the geisha allele from a breeding population may allow for quantitative improvement in total anthocyanin production. Observations on petal number inheritance revealed that seedlings produced a continuous distribution of petal numbers between the petal numbers of the two parents, with occasional transgressive segregants. The highest average petal numbers were found in seedlings resulting from the cross of double-flowered taxa. Flower size (petal area), varied significantly among cross combinations and flower forms. The largest petals were observed in the seedlings of single-flowered by double-flowered crosses. Concomitant upregulation or expression of genes controlling laminar growth in stamen may not only result in petaloid stamen, but may also result in increased laminar growth in the true petals, resulting in wider, overlapping petals. However, further work must be

An asterisk (*) following a name indicates the presenting author.
Inheritance of Foliage and Flower Color of *Hibiscus Moscheutos* Hybrids

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University of Georgia, Athens, GA, USA

Hardy hibiscus (*H. moscheutos*) is a perennial shrub with showy blooms and is hardy from USDA zones 4–9. Selections of hardy hibiscus were crossed with a Florida native, *H. moscheutos var. incanus* (swamp rose mallow), for introgressing various traits. F₁ and F₂ seedlings varied in phenotypic traits, particularly foliage and flower color. The objective of this study was to determine inheritance of these two traits. Two experimental lines of *Hibiscus moscheutos* were each crossed with swamp rose mallow and resulting F₁ populations were evaluated Summer 2015. Seed for evaluating both traits was obtained from crosses and selfings conducted Summer 2016. Seedlings were planted Spring 2017 and evaluated Summer 2017 in Watkinsville, GA. From the F₂ populations, foliage color was observed to fit the Mendelian inheritance ratio of 3:1, where red foliage is dominant to green. To evaluate this observation, selfing of each original parent plant and a plant from each of the F₁ populations was conducted and progeny were evaluated for foliage color. Results indicated the two parental experimental lines to be homozygous dominant ($\chi^2 = 0$ for each) for a gene controlling foliage color, and the other, homozygous recessive, having all green foliage ($\chi^2 = 0.14$). Progeny from selfing a red foliage plant from each of the F₂ populations also fit the expected red:green foliage ratios ($\chi^2 = 0$ and 0.03). To evaluate inheritance of flower color, two groups of crosses were conducted: one, using a red-flowered parent with white to blush-colored parents and the second, using two red-flowered parents. Reciprocal crosses of *Hibiscus moscheutos* ‘Robert Fleming’ USPP# 14,776 with three experimental lines of *H. moscheutos* indicate red flower to be maternally inherited from ‘Robert Fleming.’ When ‘Robert Fleming’ was pollinated with each of the three white/blush-flowered experimental lines, progeny displayed only red/dark pink flowers. Whereas, when ‘Robert Fleming’ was used as pollinator on the three experimental lines, progeny exhibited flowers ranging from white, pink to red. Additionally, selfing of *H. moscheutos* ‘Robert Fleming’ yielded only red-flowered progeny. Reciprocal crosses between two intraspecific experimental lines of *H. moscheutos* bearing red flowers yielded progeny with flower color segregating out to red, pink, and white. Flower color ratios observed suggest the trait to be controlled by two genes. This information on inheritance of foliage and flower color can prove useful for further breeding work of hardy and swamp rose mallow hibiscus.

Specified Source(s) of Funding: Star Roses and Plants
Bacter asiaticus (CLas) and is vectored by the Asian citrus psyllid. About 80 to 90% of citrus trees in Florida are estimated to be infected by CLas; resulting in >70% decline in citrus production over the last decade. HLB-affected plants showed blotchy motting on leaves, twigs dieback, reduced fibrous root density, and stunted growth which leads to the shorter lifespan. Preliminary studies show that enhanced mineral nutrition helps in maintaining growth and productivity of CLas-infected plants. Mineral nutrition seems to overcome stress in HLB-affected plants; however, soil pH directly impacts on specific nutrients availability and uptake pattern. Therefore, a comparative greenhouse study was conducted to evaluate the nutrient uptake with different pH ranges in healthy and HLB-affected plants. This study was designed as a completely randomized block design with four replicates of each healthy and CLas-infected plants grown in hydroponic culture (with Hoagland solution). The pH range i.e. 6–6.5, 6.5–7, 7–7.5, 7.5–8 and 8–8.5 were maintained in Hoagland solution by adding acid/base on alternate days for five-week growing period. Under pH 6–6.5 range, CLAs-infected plants showed increased chlorophyll content (%), leaf number and shoot growth (% increase), leaf nitrogen and zinc content; and, decreased calcium and manganese leaf contents compared to higher pH ranges. Hoagland nutrient analysis showed increase in nitrogen, potassium, calcium, magnesium, and boron uptake at pH 7–7.5 range in healthy and HLB-affected plants. Overall, HLB-affected plants showed better growth at pH 6–6.5 than healthy plants. In addition, the interaction of HLB and reactive oxygen species (ROS) and genes expression analysis related to nutrients will be determined. With this study, we expect to develop better understanding of HLB, pH of growing media, and nutrient absorption interaction with changing pH; these results will help in selection of favorable pH range for fertigated citrus to maintain optimal plant growth under HLB prevailing conditions for commercial groves.

3:45 PM – 4:00 PM

Rehabilitation of HLB Infected Citrus Groves by Changes in Cultural Practices and Tree Nutrient Amendments

Frank Dean*
LidoChem, Inc., Hazlet, NJ, USA
C. Ramsey
USDA-APHIS, Fort Collins, CO, USA

The citrus disease Huanglongbing (HLB or citrus greening), is a bacterial disease that is widespread throughout Florida. Thus far, HLB has been difficult to manage due to the nonspecific disease symptoms, dissimilar environmental stresses, visible symptoms only revealed long after probable infection, differences in host – pathogen recognition and containment, and, host tolerance to the bacterium. We hypothesized citrus greening is caused by induced nutritional deficiencies enhanced by environmental stresses, and, from cultural practices; these stresses induce changes in soil microbiota, microbial induced nutrient deficiencies, disruptive host metabolism, and, host immune system challenges. Cultural practices and environmental stresses may induce metabolic disorders, changes in morphology, and disease susceptibility. When each of the stresses is addressed, metabolic disorders are corrected and morphology reverts to the norm. Program changes made to cultural practices included reduced pesticide use and rates, lower fertilizer inputs, applications of soil amendments and foliar applications of selected nutrients. These changes reduced or eliminated symptoms of citrus greening, reduced or eliminated HLB rDNA titer, increased yield and quality, and, elimination of Post Bloom Fruit Drop.

4:00 PM – 4:15 PM

Ground Applied Overdoses of Manganese Show a Therapeutic Effect Against HLB in Established ‘Vernia’ Sweet Orange Trees

Flavia Tabay Zambon*
University of Florida, Lake Alfred, FL, USA
Davie Kadyampakeni
University of Florida, Lake Alfred, FL, USA
Jude Grosser
University of Florida, Lake Alfred, FL, USA

The Florida citrus industry has been devastated by the bacteria Candidatus Liberibacter asiaticus (CLas), the probable causal agent of greening (HLB). Blotchy mottled leaves, phloem plugging, root depletion, misshapen fruit, severe defoliation, and fruit drop are some of the HLB symptoms in infected trees. Micronutrients play an important role in conferring plant disease tolerance. Manganese (Mn) protects the cells against the damaging effects of free radicals, and activates enzymes involved in: nitrogen metabolism, flavonoid, and indole acetic acid pathways. Boron (B) is required for sugar transport, carbohydrate metabolism, cell wall synthesis and cell structure. Our hypothesis is that manganese and boron applied in excess of current recommendations as controlled released fertilizer (CRF) can mitigate HLB symptoms in field established trees. Commercially established ‘Vernia’ grafted onto Rough Lemon trees were divided into eight supplemental CRF nutrition treatments (two and four times the recommended doses) in a randomized complete block design in St. Cloud, FL. Treatments were composed of six trees in duplicate as follows: 1) No extra nutrition (control), 2) Harrell’s – St. Helena Mix (H) 0.9 kg per tree; 3) Harrell’s with 32g of Florikote Polymer Coated Sodium Borate (B) per tree; 4) Harrell’s with 90g TigerSul® Manganese Sulfate (Mn) per tree; 5) Harrell’s with 32g of B + 90g of Mn per tree; 6) 180 g of Mn per tree, 7) 64 g of B per tree, and 8) 180g of Mn + 64g of B per tree, applied every 6 months, for 5 years. Leaf nutritional analyses were done in March and September 2017, as well as qPCR for CLas in December. Low bacteria presence, meaning higher CT values were observed in trees that received four times the recommended dosage of manganese (180 g Mn). No significant differences in juice characteristics, canopy volume and trunk section area were found between control and 180g Mn treated plants. Soil and leaf nutrients B, K, Mn, and Zn were signifi-

An asterisk (*) following a name indicates the presenting author.
cantly different among treatments at various times in the study. We conclude that citrus trees supplied with excessive amounts of Mn bacteria populations are suppressed by its therapeutic effect. This response was not observed when Mn and B were combined in overdose, suggesting an antagonistic effect from B. When overdosed, Mn might restore biological functions and tree tolerance lost from nutritional imbalances caused by HLB. Further studies are needed to elucidate which pathways differ from overdosed and conventionally fertilized trees.

*Specified Source(s) of Funding:* The Lee Family and all fertilizers donated by Harrells and TigerSul.

4:15 PM – 4:30 PM

**Citrus Resilience under a Category 4 Hurricane: Lessons from Irma in South West Florida**

Fernando Alferez*
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Since the strike of four hurricanes in South West and Central Florida in 2004 (Charley, Frances, Ivan, and Jeanne), and then Wilma in 2005, citrus growing areas in the state were hurricane-free for more than a decade. However, the disease known as citrus greening or HLB was first detected in Florida in 2005. Under HLB pressure, that has decreased production by 70% in 10 years, Florida Citrus Industry has adopted several strategies to survive while coping with the disease, since it is now endemic and there is no cure currently available. These strategies include, but are not limited to, developing and testing new varieties (rootstocks and scions) with tolerance to the disease. On 10 Sept. 2017 Irma made landfall as a Category 4 hurricane in South West Florida, severely affecting citrus groves aligned in her path. As a result, USDA Citrus Crop Forecast for this year has dropped from roughly 70–45 million boxes. Being the situation dramatic for the Industry, still there was useful information during Irma’s aftermath that we have been able to share with the rest of the citrus community in our state. In addition, these observations have seeded new research initiatives. Examples include rootstock behavior in response to winds and survival of new varieties after extensive flooding and wind damage. Trees from Hamlin and Valencia grafted on different rootstocks behaved differently in response to hurricane-force winds: Around 50% of trees grafted on the trifoliate dwarfing rootstock ‘Flying dragon’ were uprooted, whereas this only happened on less than 6% of trees on Swingle citrulmo or Cleopatra mandarin, irrespective of the scion. The mandarin hybrid LB8-9, also known as SugarBelle [Clemetine’ mandarin (Citrus reticulata) × ‘Minneola’ tangelo] has shown tolerance to HLB and is now being adopted by many growers in Florida willing to produce high quality mandarins for the fresh market. In an experimental plot of 6-year old trees grafted on Carrizo rootstock, winds uprooted 70% of the trees. These trees were laying on the ground for up to three weeks before planted back. After winter, all the trees have survived, and spring flush, flowering, and fruit set was more abundant and occurred two weeks earlier as compared to standing trees. Taken together, these data increase our understanding and will lead to better management of stresses associated with hurricane conditions, allowing citrus growers to make better decisions in a timely manner.

**Vegetable Breeding 2**

*Moderator:* Gehendra Bhattarai
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4:00 PM – 4:15 PM

**Cucurbit Powdery Mildew Races on Melon: Current Status in the United States**

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Cucurbit powdery mildew (CPM) is caused most frequently by two fungal species, Golovinomyces orontii and Podosphaera xantheii (Px), that are highly variable in virulence. The former organism has not been reported on melon in the United States since the 1960s, while the latter organism is consistently reported on melon across the country. Variability in CPM virulence, recorded as different physiological races, was first observed in the U.S. in 1938, when race 2 appeared shortly after the release of race 1-resistant ‘PMR 45’ for Imperial Valley, Calif. production. Px race 3 appeared in 1977 in Weslaco, Texas. Px race 1 was present on spring and fall season melons in Imperial Valley in 2001–02, but in 2003 a new race, designated S, was observed in a spring melon production field and race differential research plots. Race S infected all the CPM melon race differentials in common use at that time. Px races 1, 2, and S occurred on spring melons in Imperial Valley, 2004–17. In Yuma, Ariz., ~80 km distant from the Imperial Valley research plots, race S first appeared in Spring 2004, and recurred there during the spring seasons of 2005, 2007–08. Px race S has not been observed on fall melons in Yuma or Imperial Valley; only race 1 was observed in those areas in Fall 2002–07. Px races 2, 5, 3.5, and S were present at 3 locations in the Central Valley, California in August and September 2003–17. Px race SD, which infects all known Px melon race differentials was first isolated via single spore transfers from race S in 2003, and has been present in a greenhouse at Salinas since 2012. Twelve California field isolates and their single-spore sub-strains collected 2014–15 revealed additional virulence variation, including one similar to race pxCh1, in controlled-inoculation greenhouse tests of 11 CPM race differentials. Such virulence variation has not been reported in other parts of the U.S., with the exception of one unconfirmed report of race S in Georgia. Px races 1 and 2 occur...
Genetic resistance is the most preferred management strategy for powdery mildew (Podosphaera xanthii) and downy mildew (Pseudoperonospora cubensis) in cucurbits. However, traditional breeding for resistance to the two diseases is resource intensive, often requiring decades’ long phenotyping and selection processes. As an alternative, durable and broad-spectrum resistance to powdery and downy mildew can be obtained through loss-of-function of susceptibility genes in elite breeding material. Susceptibility genes for powdery mildew [Mildew-Locus-O (MLO)] and Powdery Mildew Resistance (PMR)] and downy mildew [Downy Mildew Resistance (DMR)] have been functionally proven in model plant species. Previous studies have reported candidate MLO genes for Citrullus lanatus and Cucurbita pepo, but none for C. maxima and C. moschata. However, no PMR or DMR candidate genes have been identified for C. lanatus or any of the Cucurbita species. The current study used bioinformatics approaches based on sequence similarity, phylogenetic relationships and presence of conserved domains to predict candidate MLO genes in C. maxima and C. moschata and PMR and DMR genes in C. lanatus, C. pepo, C. maxima and C. moschata. Four MLO homologs in C. maxima and five in C. moschata clustered within Clade V, a clade containing all MLO susceptibility genes in dicots, and had highly conserved transmembrane domains and C-terminal PM interaction motif. Sixty-three candidate PMR genes were identified among the four species, 16 of which had close similarity to functionally proven PMR homologs in model species. Similarly, 37 candidate DMR genes were identified 12 among which clustered with functionally proven DMR homologs in model species. Functional analysis of the genes identified in the current study will reveal their role in pathogenesis and assess their potential for manipulation through gene editing methods to generate novel resistant plant genotypes.

Field phenotyping and genome wide association analysis for downy mildew resistance in USDA spinach germplasm

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Spinach (Spinacia oleracea) is an important cool-season leafy vegetable crop. A significant increase in spinach consumption in last two decades in the United States is attributed to an increased consumer health-consciousness. Downy mildew (DM) caused by an obligate oomycete Peronospora effusa, is an economically important disease in spinach. Many new races (> 10) have been identified in last two decades and such a rapid increase in the number of races threatens the sustainable production of spinach. DM can be managed using a number of strategies, but disease resistance is the most practical and economical management practice. Disease resistance is particularly critical for organic spinach production, which makes up approximately 50% of the market. The development of durable resistance of the downy mildew pathogen is critical. A total of 400 spinach genotypes, collected from a wide geographical region and maintained at NCRPIS, were evaluated at the USDA research station, Salinas, CA in Oct. 2017. The purpose of the field evaluation was identify field resistance to the downy mildew pathogen under natural disease pressure under field conditions. Field screening for downy mildew resistance can potentially identify partial resistance governed by QTL. The selection for QTL resistance in spinach to the downy mildew pathogen can improve durability of resistance. The spinach accessions evaluated were originated from 37 countries and belong to five different species but most are S. oleracea. Disease severity was rated on a scale of 0-100% based on a percentage of leaf area showing signs or symptoms of downy mildew. A wide variation in downy mildew disease severity was observed among the evaluated spinach genotypes. A whole-genome resequencing of all evaluated spinach genotypes is underway, and the SNPs marker identified from the population-resequencing approach will be used to conduct genome-wide association analysis. Identification of markers associated with minor and major resistance alleles can be used for gene pyramiding to improve the durability of resistance of spinach cultivars to the spectrum of races of the downy mildew pathogen.
4:45 PM – 5:00 PM

**Evaluation of Resistance in Capsicum species to Powdery Mildew and Characterization of the Camlo2 Locus**

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Since its introduction to New Mexico in the 1990s, powdery mildew, caused by *Leveillula taurica* (Lév.), has been a major disease on chile peppers. Powdery mildew can lead to severe plant defoliation, resulting in significant quality and yield losses. Applications of fungicide can be effective in managing the disease; however, early detection and thorough coverage of the plant is required. The most economically and environmentally sustainable solution is breeding for resistance. The Chile Pepper Institute at New Mexico State University grows an annual Teaching Garden at the Fabian Garcia Science Center in Las Cruces, NM. During the 2017 growing season, environmental conditions were highly favorable for powdery mildew development, and severe infection was observed. Under natural infection, 152 accessions, including six *Capsicum* species, were evaluated for resistance. Of the 152 accession, 53 accessions would be considered resistant. When examining across species, 18 *C. annuum* accessions were resistant, as well as 11 *C. baccatum*, 16 *C. chinense*, 5 *C. frutescens*, 1 *C. chacoense*, and 1 *C. rhomboideum* accession. A disease index ranging from 0 to 5 was used to score individual leaves of the plant. Accessions were considered resistant if they scored a 0 or 1. In addition to the field study, characterization of a novel susceptibility gene, *Camlo2*, was conducted in the resistant accession, HV-12, and the susceptible cultivar, ‘Maor’. A single nucleotide polymorphism (SNP) was identified and a marker was developed. Select accessions from the field study were screened. The marker identified all evaluated resistant accessions; however, was not accurate for all susceptible accessions. This study provides the first multiple species evaluation of powdery mildew resistance among *Capsicum* species in New Mexico. It also provides preliminary evidence for genetic control of resistance in *Capsicum* populations. The identified SNP can be used for early screening of resistant material. This study provides a valuable base for continued breeding efforts, especially in the more commercially significant, *C. annuum*.

5:00 PM – 5:15 PM

**Rhizoctonia Screening of the USDA-NPGS Table Beet Germplasm Collection and Commercial Cultivars**

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*Rhizoctonia solani* is a fungal pathogen affecting many crop families. Anastomosis groups (AG) IIIB and IV affect table beet (*Beta vulgaris* subsp. *vulgaris*) and *Rhizoctonia* infections can cause severe yield losses. Resistance to this fungus is available in sugar beet lines, but has yet to be explored thoroughly in table beet. Table beet is an important crop in the state of Wisconsin with over 3,500 acres grown annually for processing. In Fall 2016 and Spring 2017 greenhouse screening techniques for *Rhizoctonia* in table beet were developed. Ten genotypes were screened: three open-pollinated cultivars, three hybrids, two publicly-available inbred lines, and resistant and susceptible sugar beet breeding lines (obtained from the USDA sugar beet breeding program, Ft. Collins, CO). Detroit Dark Red, Red Ace, Camaro, and W364 performed comparably to the resistant sugar beet (mean disease rating = 1.04) with mean disease ratings of 1.69, 1.47, 1.20, and 1.35, respectively. In Spring 2018, two screens were conducted. The first evaluated 94 PI accessions obtained from the USDA-NPGS in Pullman, Washington. The second evaluated over fifty commercially available cultivars and publicly-available inbred lines. Resistant and susceptible sugar beet breeding lines and one inbred line were included as checks. Each screen was replicated over time. Plants were artificially inoculated at 8 weeks after planting. At 3 and 5 weeks post-inoculation, roots were given a disease score based on their internal and external characteristics. The results from these screens and future screens will be useful in identifying sources of resistance within *Beta vulgaris* which can be used in breeding for resistance to *Rhizoctonia*. The research described in this study will be helpful in developing table beet lines with resistance to *R. solani*.  

**Specified Source(s) of Funding:** Midwest Food Products Association

5:15 PM – 5:30 PM

**Screening of Solanum Species for Resistance to Target Spot of Tomato**

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Target spot, caused by *Corynespora cassiicola* (Berk. & Curt) Wei, has become a significant threat to tomato production in Florida in recent years. The disease infects tomato foliage and fruits and can result in dramatic yield losses under conditions favorable for disease development. Recent studies have demonstrated increased aggressiveness and fungicide resistance in *C. cassiicola* populations in the state. In an effort to identify potential sources of host resistance, 83 tomato accessions representing nine different *Solanum* spp. were screened for resistance to *C. cassiicola* using a newly developed seedling assay. Initial results identified seven of these accessions as resistant and 22 as moderately-resistant. Assays were subsequently repeated for 12 of the better accessions, and resistance relative to susceptible.
S. lycopersicum controls was confirmed in each of the 12 accessions. Resistance was identified among S. lycopersicum, S. habrochaites, S. cheesmaniae, and S. pimpinellifolium species. Two S. cheesmaniae accessions (LA1042 and LA0932) and two S. pimpinellifolium accessions (LA1043 and LA2093) demonstrated the highest levels of resistance among the 12 accessions. Ongoing research efforts seek to further validate resistance levels among these accessions using seedling disease screens and field trialing of mature plants. Crosses between resistant accessions and elite germplasm are also underway and will be used to characterize gene action and to begin introgression of resistance into cultivated tomato.

Specified Source(s) of Funding: Florida Specialty Crop Block Grant

5:30 PM – 5:45 PM

Developing Methods to Screen for Heat Stress Tolerance in Lima Bean (Phaseolus lunatus) based on Effects of High Night Temperature Stress on Reproductive Structures

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Heat stress reduces yields of May and early June-planted lima bean (Phaseolus lunatus) in the Mid-Atlantic region of the United States. High night temperatures during flowering and seed development can reduce or delay pod set, resulting in delayed harvest, lower yield and split pod sets. Breeding heat tolerant baby and Fordhook type lima beans is one goal of the University of Delaware lima bean breeding program. Greenhouse experiments were used to characterize the response of several lima bean genotypes to high versus ideal nighttime temperatures in order to better understand the mechanism by which high night temperatures reduce yield. Higher amounts of pollen shed onto the stigma and style under heat stress are correlated with higher yield under heat stress, and that there is genotypic variation for this trait. Additionally, some heat sensitive genotypes exhibited a number of physiological changes to reproductive structures while under heat stress, some of which may interfere with reproduction and affect yield: lower in vitro germination of pollen collected from the pistil, extrusion of the stigmatic pad from the keel and anther indehiscence. Other aspects of reproduction, such as stigma receptivity, are affected in some heat sensitive genotypes, but not others. Vegetative growth was not reduced by high night temperatures. Plants grown under stressed and unstressed conditions produced similar shoot dry weights. Heat sensitive plants produce more leaves and stems under high temperature conditions, compensating for the reduction in seed weight. In the University of Delaware lima breeding program, characterization of some of the physiological changes to reproductive structures that are associated with heat sensitivity is being used to screen diverse germplasm and breeding lines in order to select for heat tolerance.

Specified Source(s) of Funding: Delaware Specialty Crop Block Grant

5:45 PM – 6:00 PM

Short-day Onion Germplasm Evaluation in Southern Texas

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Disease and insect are one of the limiting factors for short day onion in Texas. The objective of the study was to evaluate Texas A&M onion germplasm for disease and insect prevalent in southern Texas. A total of 25 elite onion lines were evaluated at Uvalde and Weslaco, TX in 2016–17 and 2017–18 field season. Data were collected on yield and its components, disease and insect and quality traits. Association among traits was tested using correlation and path coefficient. Genotype, GenotypeXEnvironment (GGE) biplot was used to analyze multi-environment data. Results indicated that bulb height had the highest positive direct effect on bulb weight. A positive and high correlation was observed between foliar disease and root disease. Germplasm showed variation for diseases and insect. Texas A&M experimental lines 34154 and 34114 had higher yield and also tolerant to diseases in the first year. Second year field data are being collected in the field to validate first year data.

Specified Source(s) of Funding: Texas A&M AgriLife Research Seed Grant

4:15 PM – 4:30 PM

Higher Accumulation of Nutrients and Sugar in Pear Fruit Might be Closely Related to the Vascular Development of Petiole and Peduncle

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Potassium (K) is one of the most important mineral nutrients limiting fruit growth and development and is known as a ‘quality element’. The results from the study showed K fertilization improved the development of the vascular bundles in pear petioles and fruit peduncles and enhanced the synergistic effect of the genes involved in nutrients and sugar transport. Magnesium (Mg) concentrations in the leaves, petioles and fruit peduncles were significantly lower under the K treatments than under the
control treatment, but the concentrations of K, calcium (Ca), and Mg in the fruit gradually increased as the K application rate increased. Leaf Mg and Ca were antagonistic to K, and this phenomenon may be related to the up-regulated expression of Mg transporters (MRS2-1 and MRS2-3) under low K treatment. The concentrations of sorbitol, sucrose and total sugar in the leaves and fruit at maturity significantly increased in response to K supply. The improvement of sugar concentration was closely related to the up-regulation of the expression of sucrose transporter (SUT) and sorbitol transporter (SOT) genes. In turn, these effects promoted the transport of nutrients and sugar from sources (leaves) to sinks (fruit) to increase the accumulation of sugar in the fruit.

**Specified Source(s) of Funding:** This research was supported by the fund of China Agriculture Research System (CARS-28-10)

4:30 PM – 4:45 PM

**Determining Early Season Aluminum Tissue Values in Hydrangea Leaves to Predict Blue Sepal Color**

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Hydrangeas (*Hydrangea macrophylla*) contain an anthocyanin pigment within the sepal that naturally produces a pink or red color. In the presence of aluminum (Al) the pigment will bind with the Al producing a blue or purple color. The current method for producing blue hydrangeas is to apply 3–4 weekly drench applications of aluminum sulfate ([Al$_4$(SO$_4$)$_3$]). Growers lack a way to verify if sufficient Al applications were made. The purpose of this study was to determine if early season Al leaf tissue values could be used to predict blue sepal color. We treated ‘Early Blue’ hydrangeas with 0, 6, 8, 9, 10, 12, and 15 g of Al$_2$(SO$_4$)$_3$ per pot applied as a drench beginning two weeks after transplanting. The 6, 8, and 10 g rates were split over two applications and the 9, 12, and 15 g were split over three applications. We measured Al levels in the leaf tissue and substrate leachate by ICP analysis beginning one week after final drench application and continued weekly until bloom. Sepal colors were evaluated by visual analysis and measured using a handheld colorimeter. The plants receiving 0, 6, 8, and 9 g Al$_2$(SO$_4$)$_3$ produced the least blue sepals ranging in color from blueish pink to purple. Plants receiving 12 and 15 g Al$_2$(SO$_4$)$_3$ produced the most blue sepals. Plants treated with 15 g of Al$_2$(SO$_4$)$_3$ were stunted in growth and displayed leaf scorch symptoms. Leaf symptoms were likely due to stunted root systems caused by higher Al application rates. The Al leaf tissue values were consistently higher in the 12 g and 15 g treated, which produced the bluest sepals. At week 6 the plants treated with 12 g [4 g Al$_2$(SO$_4$)$_3$], at three applications] had Al tissue values of 1724 ppm, which was significantly higher than the plants treated with 8 g [4 g Al$_2$(SO$_4$)$_3$], at two applications] that had 867 ppm Al. At week 7 the plants treated with 15 g [5 g Al$_2$(SO$_4$)$_3$], at three applications] had Al tissue values of 2152 ppm, which was significantly higher than the plants treated with 10 g [5 g Al$_2$(SO$_4$)$_3$], at two applications] that had 1454 ppm Al. Based on these findings growers producing ‘Early Blue’ hydrangeas should target leaf tissue values between 1300–2000 ppm Al by weeks 6 to 8 of forcing in order to produce blue hydrangeas.

**Specified Source(s) of Funding:** North Carolina Department of Agriculture and Consumer Services (Agronomic Division), North State University Floriculture, The Fred C. Gloeckner Foundation Inc.

4:45 PM – 5:00 PM

**Quantifying the Acidic and Basic Effects of Vegetable and Herb Species in Peat-based Substrate and Hydroponics**

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Greenhouse crop species differ in their effects on root zone pH in soilless and hydroponic production. Objectives of this study were to 1) quantify acidic and basic effects on the root zone pH for eight vegetable and herb species grown in peat-based substrate and hydroponic nutrient solution and 2) determine NH$_4^+$:NO$_3^-$ nitrogen ratios expected to have a neutral pH reaction for each species during their vegetative growth phase. In one experiment, plants were grown for 33 days in substrate containing 70:30 (peat:perlite, by volume) and were fertilized with a nutrient solution containing 7.14 mEq L$^{-1}$ N and NH$_4^+$ : NO$_3^-$ ratios ranging from 0:100 to 40:60. In the second experiment, the same species were grown for six days in hydroponic nutrient solutions at 7.14 mEq L$^{-1}$ N with NH$_4^+$ : NO$_3^-$ ratios ranging from 0:100 to 30:70. Acid and base produced in the root zone and cation versus anion uptake were quantified in both experiments. Species produced from 2.18 mEq of acid (lettuce) to 2.65 mEq of base (arugula) in substrate and from 2.82 mEq (lettuce) to 3.86 mEq (eggplant) in the hydroponic solution. Acid and base per gram of dry mass gain (plant growth) ranged from 0.66 mEq g$^{-1}$ acid (lettuce) to 1.74 mEq g$^{-1}$ base (arugula) in substrate and from 1.35 mEq g$^{-1}$ acid (lettuce) to 1.32 mEq g$^{-1}$ base (arugula) in solution. Plants produced acidic when there was a greater net uptake of cations over anions, and produced base with a net uptake of anions. Overall, arugula had the greatest uptake of anions compared with other species. Percent NH$_4^+$-N of total N expected for a neutral pH ranged from 0% (cucumber) to 55% (arugula) in substrate and from 6% (lettuce) to 32% (arugula) in hydroponic solution. Evaluating the effects of vegetable
and herb species on root zone acidity and basicity can be used to select a neutral $\text{NH}_4^+:\text{NO}_3^-$ fertilizer ratio for substrate and hydroponic production.

5:00 PM – 5:15 PM

How Should We Help Growers Follow the Fertilizer Recommendations for Chip Potato Production in Florida?

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Phosphorus is relatively immobile in soil under moderate soil pH. As a result of long-term P applications in potato production area, the soils are high in P on average of 351 mg/kg Mehlich-3 P (range 81–599). This average P level is almost 8 times greater than the UF/IFAS recommendation for zero P application. However, potato growers keep applying 112 kg/ha every growing season because they can have 5% to 10% tuber yield response which is just their profit margins. To help growers optimize their phosphate management, on-farm trials with six P levels (0, 45, 90, 135, 179, and 224 kg/ha P$_O_4$) were conducted at HAEC, Hastings, FL from 2015 thru 2017. Plot size was 49.55 square meters (12.2 m × 4.1 m). Randomized Complete Block Design was used with four replicates. Potato cultivar was ‘Atlantic’. The results showed that zero P application had significantly lower tuber yield than 45 kg/ha P application. The yield difference was 7% or 17%. The soil pH was as low as 4.8 in the growing season. The soil had 563 kg/ha aluminum and 131 kg/ha iron. The P in soil was tied up with active aluminum and iron. Phosphate fractionation showed that approximately two thirds of P were locked out by the metal ions. The data show that 45 kg/ha P is sufficient for potato production in the Hastings area in Florida.

Specified Source(s) of Funding: Western SARE

5:15 PM – 5:30 PM

Biochar As a Soil Amendment and Nutrient Regulator

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Biochar, a product of biomass that is heated in an oxygen limited environment (pyrolysis), has been reported to improve soil quality and increase plant growth. To quantify and further characterize such effects of biochar, three experiments were conducted: 1) a greenhouse trial on an acidic tropical Ultisol, which evaluated the aluminum (Al) detoxifying potential of biochar, using Desmodium intortum, an Al sensitive forage legume as the test plant; 2) a greenhouse trial using nitrogen (N) fertilizer sources, both organic and synthetic, with and without biochar, which measured the capacity of biochar to regulate/release N to Chinese cabbage (Brassica rapa Chinensis group) growth; and 3) a field trial on a highly weathered Oxisol, which documented the long-term, field-condition effects of biochar on a variety of crops [sweet corn (Zea mays), okra (Abelmoschus esculentus), and soybean (Glycine max)]. Our results show: 1) At an application rate of 2.5% (approximately 25 tons/ha), a kiawe-wood biochar could reduce Al toxicity and increase D. intortum growth as much as lime ($\text{CaCO}_3$) applied at 3 cmol/kg (1.5 tons/ha). $\text{CaCO}_3$ equivalent (represented by ash content) and COOH, OH functional groups on the biochar surface were likely responsible for these effects. 2) At a same total N rate of 200 kg/ha, cabbage yield was nearly doubled in the presence of a wood-based biochar (at 2%) than when urea or organic N fertilizer was applied alone, and yield increased became even more pronounced in the second harvest than in the first. This increased N use efficiency could be attributed to biochar properties, such as large surface area and numerous tiny pores. 3) Under field conditions, corn yield (first season) was nearly doubled in the presence of 2% biochar (derived from macadamia shells) when N was applied as urea or blood meal (10% total N) at 150 or 300 kg/ha rate. Interestingly, the effect of biochar on plant growth seemed to extend beyond N nutrition because the treatments receiving biochar but no N input also out-yielded those having N input but no biochar. The prolonged/aging effect of biochar will be further studied in future time.

Specified Source(s) of Funding: Western SARE

5:30 PM – 5:45 PM

Foliar Application of Biostimulant As a BMP Tool to Improve Tomato Production in Florida

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A pot study was conducted to investigate the effects of individual biostimulants on tomato (cv. ‘Phoenix’) growth and yield in greenhouse in fall 2017. Six different biostimulants: CP$_1$, CP$_2$, BS, CP2+BS, Competitor, and Water (control) were respectively foliar-applied at three different stages: pre-bloom, fruit setting and color change. A control (only water sprayed) was paralleled. The contents of different nutrients like Ca, K, Mg and P in leaves and roots were also determined. Plants treated with biostimulants had improved levels of Ca, K, Mg

An asterisk (*) following a name indicates the presenting author.
An asterisk (*) following a name indicates the presenting author.

5:45 PM – 6:00 PM

**Wastewater-grown Algae As Fertilizer**

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Drawbacks of synthetic fertilizers led us to explore wastewatergrown algae as biologically based alternative. Such algae may allow for the recycling of polluting nutrients for use as fertilizer. Six formulations of extruded algal pellets comprising various amounts of polyactic acid, soy flour, biochar, and wastewatergrown algae were compared as fertilizers for African marigold (*Tagetes erecta L.*) and gerbera daisy (*Gerbera jamesonii* Bolus ex Hooker f.). A synthetic, controlled-release fertilizer (CRF), and a commercially available co-product of wastewater treatment, also were studied. Fertilizers were incorporated throughout the root-zone at 641.2 g m⁻³ of N, the rate of N that corresponded to the CRF label recommendation. Plant growth index, shoot dry weight, and shoot nutrient concentrations, as well as substrate pH and EC, were measured after 40 and 64 d for marigolds and gerbera daisies, respectively. Extruded bio-based fertilizers increased the dimensions and weights of shoots of both species compared to those measures of unfertilized plants and of plants supplied with the commercially available co-product of wastewater treatment. Growth of plants provided with certain extruded bio-based fertilizer formulations were similar to those measures of plants fertilized with CRF. Nutrient deficiency symptoms and associated insufficient nutrient concentrations of shoots were evident in plants provided some formulations of bio-based fertilizers and the commercially available co-product of wastewater treatment. Bio-based fertilizers did not negatively impact substrate pH or EC. Overall, extruded bio-based fertilizers were effective fertilizers, though our results show that growth of marigolds and gerbera daisies depends on the formulation of these materials. We conclude that use of algae as a source of biologically sequestered and recycled nutrients has potential for reducing environmental impacts associated with nutrient management of horticultural crops.

6:00 PM – 6:15 PM

**Increasing Farmer and Undergraduate Participation in On-farm Research on Vegetable Farms in Indiana**

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This project introduced participatory research to vegetable farmers in the North Central region, utilizing biochar, a soil amendment with the long-term potential to improve soil fertility and crop yields in the region. The growers who participated in the study are considered early adopters of new technology and are interested in low-input agriculture. The project increased the knowledge of the potential effects of biochar on soil fertility and the potential for reduced fertilizer inputs, by providing the growers with information on biochar from on-farm participatory research. The research was conducted in a variety of climatic areas of the state and on different soil. Final results from the participatory research were inconclusive for biochar impacts on vegetable production but we did find that the knowledge gained from the project helped guide the participating growers to conduct additional research. The project also created a model for using interns in on-farm participatory research. Our novel approach of pairing undergraduate students with growers in a structured summer research project resulted in increased understanding among student participants of farm life and farm management (for example students gained an appreciation for working conditions on successful farms) and had the long-term potential for influencing student interest in farming as a career. This project also increased our understanding of how to optimally pair growers and students to provide on-farm experiential learning opportunities. The project increased the short and long-term capacity and interest of growers in conducting on-farm research and increased collaboration among farmers, extension educators, and researchers. This project built a novel and robust network for participatory learning.

**Specified Source(s) of Funding**: North Central Sustainable Agriculture Research and Education (NC SARE)
Oral Presentations

**Tropical Horticultural Crops/ Ecological Physiology/Medicinals**

**Moderator:** Russell Galanti
University of Hawaii at Manoa, Honolulu, HI, USA

4:30 PM – 4:45 PM

**Photosynthetic Capacity, Stomatal Behavior, and Ultrastructure of Chloroplasts in Carpinus putoensis Leaves during Gaseous NO\textsubscript{2} Exposure and Recovery**

Sheng Qianqian*
Nanjing Forestry University, Nanjing, China

Gaseous nitrogen dioxide (NO\textsubscript{2}) can disturb normal plant growth and trigger complex physiological response. In this study, we investigated epidermis and stomata related physicochemical responses of *Carpinus putoensis* leaves when exposed to NO\textsubscript{2} (6 mL/L) for seven time periods (0, 1, 6, 12, 24, 48, and 72 h) and 30 d of recover without NO\textsubscript{2} exposure. Our results showed that NO\textsubscript{2} exposure for 72 h led to the decline of chlorophyll content, maximal PSII quantum yield (Fv/Fm), net photosynthetic rate (Pn) compared with the control and other exposure time. Moreover, NO\textsubscript{2} exposure significantly increased the thicknesses of palisade/spongy tissue, caused swelling of the thylakoids within the chloroplasts, this thylakoid swelling could be reversed by removing the pollutant from the air flow. Recovery alleviated NO\textsubscript{2}-caused toxic effects as indicated by increased chlorophyll content, and high values of Pn and Fv/Fm. This result could provide a reference of recovering method when road greening trees exposed to NO\textsubscript{2} as the road main pollutants.

**Specified Source(s) of Funding:** The National Natural Science Foundation of China (31770752)

4:45 PM – 5:00 PM

**The Effects of Soil Amendments on Tree Growth, Yield, and Soil Properties in Mature Macadamia integrifolia Orchards**

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Alyssa Cho
University of Hawaii at Manoa, Hilo, HI, USA

Current management practices in macadamia production call for the removal of all tree litter-fall from the orchard floor to facilitate nut pick up during harvesting season, which can be up to 10 months of the year. This and derivative management practices lead to degradation of soil and environmental health and reduced nut production. Hawaiian farmers have expressed interest in sourcing alternative locally sourced soil amendments. Several new and novel soil amendments, including effective microorganisms (EM1), biochar, and soil profiling, have been identified and were compared to traditional amendments including macadamia husk mulch and wood chip mulch. The effects of these amendments on root growth, SPAD readings, and yield/quality in macadamia and soil carbon, nitrogen, pH, and electrical conductivity (EC) were studied. SPAD readings positively correlated to leaf N content with the highest r\textsuperscript{2} of .74 occurring in March of 2018. SPAD readings showed cyclical fluctuations with a negative trend in spring and a positive trend in summer throughout the year-long experiment. Husk+EM1 and soil profiling treatments significantly increased mean SPAD values within the year time frame. Mean total yield was highest for the soil profiling treatment (mean of 86.5 kg/tree). Trees under husk mulch+EM1 applications had greater mean total root weight, proteoid root weight, and a higher mean proportion of proteoid roots than all other treatments after one year. Total soil N was not significantly affected by treatments. Soil nitrate concentrations increased with the husk treatment showing the greatest increase and ammonium levels decreased. Soil pH was not affected by treatments. Soil EC was significantly increased by the husk+biochar treatment. Soil C was also not affected by treatment. Soil profiling may be an option to increase yield in the short term, but if repeated annually could cause loss of plant vigor. Application of mulches have been shown to reduce yields in the short-term, but this is not evident in this study. Husk+EM1 showed the most promising tree health results within one year. A longer term study is necessary to examine the effects of these treatments on tree and soil response variables.

5:00 PM – 5:15 PM

**Expression Profile of Floral Genes in Avocado (Persea americana Mill.) during Floral Development Promoted By Low Temperature**

Aleyda Acosta Rangel*
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Rui Li
University of California, Riverside, CA, USA

Several new and novel soil amendments, including effective microorganisms (EM1), biochar, and soil profiling, have been identified and were compared to traditional amendments including macadamia husk mulch and wood chip mulch. The effects of these amendments on root growth, SPAD readings, and yield/quality in macadamia and soil carbon, nitrogen, pH, and electrical conductivity (EC) were studied. SPAD readings positively correlated to leaf N content with the highest r\textsuperscript{2} of .74 occurring in March of 2018. SPAD readings showed cyclical fluctuations with a negative trend in spring and a positive trend in summer throughout the year-long experiment. Husk+EM1 and soil profiling treatments significantly increased mean SPAD values within the year time frame. Mean total yield was highest for the soil profiling treatment (mean of 86.5 kg/tree). Trees under husk mulch+EM1 applications had greater mean total root weight, proteoid root weight, and a higher mean proportion of proteoid roots than all other treatments after one year. Total soil N was not significantly affected by treatments. Soil nitrate concentrations increased with the husk treatment showing the greatest increase and ammonium levels decreased. Soil pH was not affected by treatments. Soil EC was significantly increased by the husk+biochar treatment. Soil C was also not affected by treatment. Soil profiling may be an option to increase yield in the short term, but if repeated annually could cause loss of plant vigor. Application of mulches have been shown to reduce yields in the short-term, but this is not evident in this study. Husk+EM1 showed the most promising tree health results within one year. A longer term study is necessary to examine the effects of these treatments on tree and soil response variables.
Avocado trees flower in response to periods of low temperature but little is known regarding the gene-environment interaction associated with floral development. In this research, temporal expression profiles of the floral promoter genes FLOWERING LOCUST (FT), LEAFY (LFY), FRUITFUL (FUL) and APETALA2 (AP2) and downstream genes associated with avocado floral organ identity, APETALA3 (AP3), PISTILLATA (PI), AGAMOUS1 (AG1) and AGAMOUS3 (AG3), were quantified in buds of ‘Hass’ avocado trees (3 years from budding) maintained under warm temperature (WT) (30 °C, 14-h day/20 °C, 10-h night) for 14 weeks relative to those of trees subjected to 8 weeks of low temperature (LT) (14 °C, 10-h day/10 °C, 14-h night) followed by 6 weeks of WT. Only LT-treated trees flowered (week 14). All trees were maintained under WT for 5 months prior to initiation of the experiment in July. At this time, buds of all trees expressed LFY, FUL, and AP2, with FT, AP3 and PI mRNA at detectable levels, suggesting the possibility that all buds were induced to flower but not determined (irreversibly commitment to floral development). By week 8 of LT treatment, bud expression of LFY, FUL, and AP2 increased to levels significantly greater than that of WT-treated trees. Two weeks after transfer of LT-treated trees to WT, bud expression of FT significantly increased followed by activation of the downstream genes AP3, PI, AG1 and AG3 by week 12. In contrast, for WT trees, bud expression of FT, AP3, and PI remained at the limit of detection, with AG1 and AG3 below the limit of detection through week 14. Taken together, our results support that LT directly or indirectly up regulated expression of the floral promoter genes FT, LFY, FUL, and AP2, which activated the downstream floral organ identity genes and resulted in flowering. The results further suggest that bud expression levels of LFY, FUL and AP2 in week 8 of LT treatment were sufficient to confer bud determinacy, since transfer of the trees from LT to WT did not prevent flowering. In light of the fact that bud expression of FT, AP3, PI, AG1 and AG3 did not occur until after transfer of the LT-treated trees to WT, our results further suggest that LT serves as both a promoter and inhibitor of flowering, preventing floral organogenesis until the low temperature stress was removed and warm temperature prevailled.

Specified Source(s) of Funding: Government funds of Rural Development Administration

5:30 PM – 5:45 PM

Studies for Productivity of Essential Oils and Aroma Constituents of Citrus junos Producing Two Different Areas in Korea

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Abstract unavailable.
Nursery Crops and Floriculture: Substrates

Moderator: Jeb S. Fields
Louisiana State University, Hammond, LA, USA

4:30 PM – 4:45 PM

(X-ray) Vision for the Future of Substrate and Plant Science?
Paul C. Bartley*
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Brian Jackson
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William Fonteno
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Horticulture offers the unique capability to design the rooting environment based on the plant’s requirements. In order to better exploit this potential, researchers require the ability to non-destructively and non-invasively characterize rooting environments and plant responses. Advancements in X-ray technology, software, and commercially available instruments have opened the door for X-ray tomography to be utilized for this purpose. At resolutions ranging between 50 and 15 μm, pine bark, peat, coir, and wood fiber substrates were imaged and quantitatively analyzed. At all resolutions, materials were effectively imaged with clear distinctions between substrate particles and pores. Increasing the scan resolution resulted in more definable internal pore structures observed most notably in pine bark. Under the appropriate conditions, plant roots, though similar in density to the surrounding substrate, can be segmented to collect qualitative and quantitative data. As plant science continues to strive for higher precision, image analysis techniques such as X-ray tomography are well placed to significantly contribute in this endeavor.

4:45 PM – 5:00 PM

Wood Fiber Substrates: Current Status of Research, Commercialization, and Use
Brian Jackson*
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In the U.S. there has been a tremendous amount of effort, resources, investments, and energies spent on the development and trialing of wood substrates and substrate components in the past 15 years. Evaluations have been conducted by academic researchers at numerous universities, substrate manufactures, private entrepreneurs, and by independent growers. Research on wood substrate components has indeed made great strides toward better understanding how, and to what extent, these materials can be used with or without peat, bark, or other traditional materials. A decade ago it was common practice to just “grind up trees” and try to get the resulting wood product to grow plants. Not anymore! Work has now evolved to be very focused to answer very specific questions, solve specific problems, and explore new opportunities relating to the use of wood components. An overview of some of the main topics relative to the commercialization and use of wood substrate materials will be covered including commercial products and their differences, fertility, pH, toxicity, and hydrological properties.

5:00 PM – 5:15 PM

Engineering a Soiless Media Using Fine Wood Dust Incorporation into a Commercial Nursery Pine Bark
Edward Bush
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Schyler Lee
Louisiana State University, Baton Rouge, LA, USA
Kathryn Fontenot*
Louisiana State University, AgCenter, Baton Rouge, LA, USA

Incorporating organic matter into a commercial nursery medium is often recommended to increase water holding and cation exchange capacity. The objective of this study was to determine the use of wood dust as an inexpensive peat moss substitute. Pine bark (5/8”) was incorporated with either: 1) 20% peat moss (pm); 2) 15% pm + 5% fine wood dust (wd); 3) 10% pm + 10% wd; 4) 5% pm + 15% wd; or 5) 20% wd. All media were amended with 2 lb N/cubic yard of a 15–9–11 complete Osmocote fertilizer and 8 lb/cubic yard of dolomitic lime. Petunia, tomato, and salvia plug growth was measured over time determining that wood dust combinations resulted in similar growth as the peat moss control. Combinations of peat moss were effective both for plant growth and reducing the cost of organic substrates. Plant growth indices and dry weight of combinations were either similar or greater than the control.

5:15 PM – 5:30 PM

Investigating the Hydraulic Conductivity of a Pine Bark Substrate and Crop Responses to Two Irrigation Regimes
Jeb S. Fields*
Louisiana State University, Hammond, LA, USA
James S. Owen
Virginia Tech, Virginia Beach, VA, USA

Soiless substrates were initially developed with high porosity to balance air to water ratio and ensure good drainage. As a result, researchers and allied suppliers tend to rely heavily upon “static” physical properties (water holding capacity and air filled porosity) to prescribe substrate recommendations which may be unachievable physical states in production such as saturation. Due to the reliance upon these minima and maxima values, conventional soiless substrates used by the nursery industry may not be efficient in regards to water resource management. Our research manipulated the hydrology of pine bark-based soiless substrates through fractioning by particle size or blending with fibrous materials (Sphagnum peat and coir) to yield varying

An asterisk (*) following a name indicates the presenting author.
substrate dynamic, hydrological parameters while maintaining static physical properties. We were successfully able to alter the unsaturated hydraulic conductivity of the soilless substrates while holding static physical properties similar. Containerized crops were then grown in pine bark-based substrates with altered hydraulic properties at optimal (Hibiscus rosa-sinensis ‘Fort Myers’) and sub-optimal (Hydrangea arborescens ‘Anabelle’) substrate water potentials. The increased substrate hydraulic conductivity allowed for added hibiscus growth and vigor, as well as increased water use at optimal substrate water potentials (–50 to –100 hPa). At suboptimal substrate water potentials (–100 to –300 hPa), increased substrate hydraulic conductivity allowed for salable hydrangea crops to be produced with < 6.5 L water, which resulted in poor crop performance in conventional pine bark substrates. It was also determined that fiber type recommendations should be influenced by growing irrigation parameters. Peat addition yielded the greatest increase in hydraulic conductivity at optimal water potentials and coir yielded the greatest increase in hydraulic conductivity at suboptimal substrate water potentials. No observable relationship existed between saturated hydraulic conductivity and production hydraulic conductivity indicating the easily measured saturated hydraulic conductivity is not a good indicator of crop water relations in soilless systems. Thus, a shift to utilization of dynamic substrate hydraulic properties can provide beneficial information to researchers and allied suppliers by enabling more informed recommendations based upon water flux that mimics actual production conditions. Moreover, optimizing the hydrology of pine bark-based substrates resulted in the water efficient production of ornamental container crops under both optimal and sub-optimal irrigation regimes. Aside from benefits associated with increased water resource management, and potential reduction in costs associated with subsequent fertility requirements, production time was reduced.

Specified Source(s) of Funding: Clean WateR3

5:30 PM – 5:45 PM

pH Buffering Capacity of Pine Bark Substrates

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Stability of substrate pH is a crucial factor in managing nutrition of container-grown crops. Substrate pH is one of the chemical parameters that influences nutrient availability but may change rapidly under some cultivation practices. Fluctuating pH can cause problems with managing nutrition in the crop. High pH buffering capacity of substrates is needed to prevent rapid changes that may lead to losses in quality and quantity of cultivated plants. Soil buffering capacity is well known and depends mainly on the clay and organic matter content, but in organic soilless growing media factors influencing this parameter are not well understood. To assess the pH buffering capacity of pine bark in comparison to peat moss, four pine bark substrates with different size particles ranging from fine to coarse (< 0.3 cm, < 0.6 cm, < 1.3 cm, and < 1.6 cm), were collected from a pine bark supplier. Three replications of each bark substrate and peat moss with weights equivalent to 100mL were placed in 250 mL jars and filled with 100mL of acid or base solution. Acid and base solutions were prepared with HCl and NaOH, respectively, at concentrations ranging from 0 to 50 meq·L⁻¹ in 10 meq·L⁻¹ increments using deionized water (18 MΩ). Jars were fitted with lids and stirred for 10 minutes. Stirring was repeated after 24 hours and pH was measured immediately to prepare pH buffering curves for each substrate. Peat moss had the highest buffering capacity. Pine bark substrates differed slightly among each other but showed lower pH buffering capacity compared to peat moss. Moreover, all pine bark substrates tended to have higher buffering capacity for bases than acids. These data can be used to better understand how substrate type and particle size affect changes in pH over time during plant cultivation.

Influence of Lime Type and Rate on Pine Bark Substrate pH

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Richard Jarrett
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James Altland
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Pine bark is the dominant component of soilless substrates in the eastern United States for producers or woody ornamental crops. The low pH of the unbuffered pine bark substrate is commonly adjusted with a lime material in order to promote proper nutrient uptake and ensure general plant health to avoid abiotic disorders. Our objective was to evaluate the long-term effect of pulverized dolomitic, pulverized calcitic, ground dolomitic, and granular calcitic lime at rates of 0, 0.5, 2.5, 4.5, and 6.4 kg·m⁻³ on pH of a < 15.9 mm aged pine bark substrates over 267 d. Each substrate was also amended with 5.5 kg·m⁻³ of an 8–9 month 18N–2.2P–10K coated, controlled-release fertilizer. All substrates were used to pot Ilex crenata ‘Bennett’s Compacta’ into 2.8 L containers. The main effect of lime material on substrate pour-through pH was not significant; however, the significance of sampling time × rate × material indicates the interaction of the three factors may provide opportunities for growers to have increased control over substrate pH. Increasing incorporation rate of lime from ≈ 4.0 to 6.4 kg·m⁻³, regardless of lime material used, resulted in a > 2 pH unit sigmoidal increase. All lime materials applied at less than 4.5 kg·m⁻³ failed to maintain the desired pH (5.2–6.5) for ornamental crop production after ≈ 50 DAI. kg·m⁻³, regardless of lime type, pH range of 5.2–6.5 currently recommended for general healthy plant growth. However, it remains uncertain if lime rates > 5.0 kg·m⁻³ would have a significant impact on increasing pH further since effectiveness of lime decreases with increasing rate beyond a critical point. Ground dolomitic lime had the least effect on increasing the substrate pH and provided...
Soybean (*Glycine max*) is a short-day plant, requiring a controlled photoperiod to produce seeds in a greenhouse environment year-round. The purpose of this experiment was to define the duration (number of weeks) of short-days soybean plants need to stimulate reproductive growth in order to not revert back to vegetative growth after exposure to long-days (16 h). Two determine soybean varieties, within the same maturity group, were sown into 32-cell flats filled with a peat-based soilless substrate, and placed in a greenhouse with a 16-h photoperiod. After 3 weeks, plants were transplanted into 22.8-cm-diameter plastic pots, and transferred to a photoperiod controlled greenhouse. The day/night temperature set points were 26.6/21.1 °C. The soybean plants were then subjected to a 14-h photoperiod for 2 weeks. Upon completion of the 2nd 14-hour week, the seven treatments of the experiment began. Plants were treated with 1, 2, 3, 4, 5, 6, or 7 weeks of a 12-h photoperiod after which plants were returned to 16-h photoperiod. A control group received a 12-h photoperiod beginning with other treatments but remained at that photoperiod for the remainder of the experiment. Number of nodes with pods, cycle time, and yield were recorded. Both varieties and all treatments showed just as good or better yield, cycle time and number of nodes with pods compared to the control. Based on the data from this experiment, photoperiod control past one week at 12-h does not have any negative impacts on yield, cycle time or number of nodes with pods for the two varieties tested.
Oral Presentations

is an under-explored, fundamental process involving carbon and water balance affecting source/sink relationships. Source leaf strength is defined by photosynthesis and carbon export; both processes being essential for growth. The process of carbon export involves additional steps downstream of photosynthesis including multiple cell lines, enzymes, and transporters which can be environmentally regulated. Our primary objective was to examine diurnal patterns of photosynthesis and carbon export via $^{14}$CO$_2$ steady-state labelling under different spectra generated by LEDs, but at similar CO$_2$ influx rates. Daily patterns showed that photosynthesis and export were supported by all wavelengths of light tested including orange and green alone. Export in the light, under all wavelengths was always higher than that at night, varying from 65-83% of daily carbon fixation depending on light intensity. Photosynthesis and export were highly correlated under all wavelengths ($r = 0.90$–$0.96$). Relative export decreased as photosynthesis increased under all wavelengths indicating an upper limit for export. Interestingly, only at the medium photosynthetic rate were differences found. At this rate, relative export under blue and orange LEDs were higher than under white and red-white LEDs. Furthermore, we also investigated the relationship between carbon export and water status. The current hypothesis is that transpiration and carbon export are linked in woody species. However, so far, our data with tomato under different spectral quality are inconclusive. Understanding the phenotypic responses of the carbon export pathway to light can aid in the optimization and implementation of LED lighting systems for controlled environment crop production.

Specified Source(s) of Funding: Agriculture & Agri-Food Canada

11:15 AM – 11:30 AM

Optimizing Supplemental Light Spectral Composition for Greenhouse Sweet Pepper Production with Top and Intra-canopy LED Lighting

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With ever-improving energy efficiency and decreasing light fixture costs, light-emitting diodes (LEDs) are becoming a promising new light source for greenhouse vegetable production. However, significant questions remain on the best light quality or spectral compositions for greenhouse fruiting vegetable (such as tomatoes, cucumbers and sweet peppers) production. Greenhouse fruiting vegetables are of tall crop, with most of leaf growth occurring in the top and middle canopy while fruit growth in the middle and bottom canopy, and these different growth processes may require different light spectra. LEDs can be used both as top lighting (above the crop canopy) and intra-canopy lighting because of their low surface temperature. Therefore, the light spectrum or spectral compositions of top and intra-canopy LEDs can be optimized for both leaf/vegetative and fruit growth. This study was conducted from Oct. to May in a large greenhouse (200 m$^2$) to compare different spectral compositions of LED top lighting and intra-canopy lighting for greenhouse sweet pepper production. The greenhouse was divided into 4 sections (50 m$^2$/section) so that two different top light spectral compositions (100% Red or Mixed (red:blue:white = 76:16:8), at the same 140 µmol·m$^{-2}$·s$^{-1}$) could be applied with two replications. Four intra-canopy light spectral compositions (Control—no intra-canopy lighting, Red (660 nm), Blue (455 nm) and White at the same 30 µmol·m$^{-2}$·s$^{-1}$) were applied to the four plots inside each section. Therefore, a total of eight vertical light spectral compositions/registimes were evaluated in the experiment. The light compositions/registimes resulted in significant difference in leaf photosynthesis, Fv/ Fm, plant productivity (total fruit fresh weight and fruit size), and fruit anti-oxidant contents. Therefore, this study has clearly demonstrated that optimized light compositions/registimes should be and can be developed for improving plant growth and fruit yield & quality in greenhouse sweet pepper production with LED supplemental lighting.

11:30 AM – 11:45 AM

Biomass Allocation and Nutrient Use Efficiency of Three Temperate Conifer Species Under Water Stress

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Two-year-old (plug+1) balsam fir [Abies balsamea (L.) Mill.], and concolor fir [Abies concolor], and one-year-old bare-root Eastern White Pine [Pinus strobus (L.)] transplants were grown under three irrigations treatments (low, medium, and high) and two fertilization treatments (low and high) in greenhouse conditions. The goal was to determine the biomass allocation and nutrient use efficiency in response to the interactive effect of irrigation and fertilization under water stress. Relative root collar diameter (RRCD), relative height growth (RHG), relative root length (RRL), fresh and dry shoot mass (FSM and DSM), fresh and dry root mass (FRM, DRM), root number, and shoot/root (S/R) ratio were measured as growth parameters. We analyzed total nitrogen concentration of needles, stems, and roots and calculated resource-use efficiency parameters, such as assimila-
Concolor fir had a greater capacity to hold acquired water and improve water uptake compared to white pine. Furthermore, concolor fir showed higher aboveground growth and S/R ratio. The fir species had a higher nitrogen concentration compared to white pine. All species had higher N concentrations in their needles followed by roots and stems. White pine seedlings showed the highest ANUE, NUE and RWR values but the lowest N/RW value. These findings have strong implications for the management of these species in horticultural systems.

During the pH trial, the maximum yields were observed at pH 6.0 and 6.2 for all cultivars. There was no variation in tipburn symptoms across pH levels. Preliminary investigations with once a week CaCl₂ foliar sprays was found ineffective in controlling tipburn. A twice a week application of 800 mg L⁻¹ Ca, showed promising results in controlling the tipburn as compared to other treatments. The yield with the 800 mg L⁻¹ CaCl₂ spray, however, was 25 g less than 0 and 200 mg L⁻¹ CaCl₂. Reducing EC of the fertilizer solution below 1.4 mS cm⁻¹ or twice a week application of 800 mg L⁻¹ Ca in the form of CaCl₂ can control tipburn of the lettuce cultivars evaluated. Application of CaCl₂ provided a better control as the symptom of tipburn was minimal and the impact on yield was minor as compared to reducing EC.
Changes in Volatile Profiles in Orange Peel Oil Extracted from Huanglongbing Affected ‘Hamlin’ and ‘Valencia’ Orange Fruit

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Huanglongbing (HLB)-affected oranges are typically green or yellow in color, rather than orange, and the latter is more common in the Florida citrus groves. The yellow color is often associated with insufficient accumulation of carotenoids (the reason for lack of orange color) in the flavedo, lack of natural shine, and shriveled peel (due to water loss). The green color is an indicator of maturity due to HLB-associated phloem malfunction and resulting retarded growth and development of the fruit. All HLB-affected fruit produced a lower volume of peel oil compared to healthy fruit, however, only green fruit showed substantially different volatile profiles from healthy fruit. The green fruit contained low concentrations of most of sesquiterpene hydrocarbons and derivatives, such as, 7-epi-α-selinene and caryophyllene oxide, some monoterpenes, and derivatives with orange/citrus characteristics, such as, methionine) coinciding with the climacteric peak in CO₂, but a similar pattern was not seen for the peel. These data are the first to demonstrate distinct differences in amino acid metabolism in the peel and pulp of banana related to their role in ripening and aroma biosynthesis.
Oral Presentations

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Banana (Musa spp.) is one of the most popular fruits worldwide, because of good taste, nutrition, and health aspects. The major postharvest concern of banana fruit is browning which reduces the marketing value and the attractiveness of fruits. The current study was designed to determine the influence of cultivar, and stage of maturity on degree of browning, polyphenol oxidase (PPO), and peroxidase (POD) in banana peel and pulp tissue. Banana cultivars varying in genome, including ‘FHIA 1’ (AAAB), ‘Hua Moa’ (AAB), ‘Kandarian’ (ABB), ‘Pisang Raja’ (AAB), ‘Saba’ (ABB) and ‘Williams’ (AAA) were harvested at full three-quarter stage of maturity and room ripened at 20 °C and 95% relative humidity. Samples were separated into four ripening stages (mature green, transition, ripe, and overripe) and total phenolics, degree of browning, PPO and POD enzyme activity of fruits were analyzed. Measured total phenolics in peel was higher than pulp in all cultivars except ‘Williams’. ‘Hua Moa’, ‘Kandarian’, ‘Pisang Raja’, and ‘Williams’ showed the highest total phenolic content at ripe and over ripe stages in peel and pulp tissues. Degree of browning increased in all cultivars with advancing of maturity in peel and pulp tissues. ‘Hua Moa’, and ‘Pisang Raja’ had the highest values of degree of browning. Whereas, ‘FHIA 1’, and ‘Saba’ showed the lowest values. The results also indicate that PPO activity of pulp was higher than that in all cultivars. In addition, activity of PPO in peel was higher than that in all cultivars. However, activity of PPO varied in cultivars with different genomes. ‘Hua Moa’, ‘FHIA 1’, ‘Pisang Raja’, ‘Williams’, ‘Kandarian’, and ‘Saba’ had the highest to lowest PPO activity in banana fruits peel. In pulp tissue, ‘Hua Moa’, had the highest and ‘Kandarian’, ‘Saba’, and ‘Williams’ had the lowest PPO activity. The highest activity of POD was observed in ‘Hua Moa’ for both peel and pulp tissue. However, POD did not show any significant activity in peel tissue of ‘Kandarin’; ‘Pisang Raja’; ‘Saba’, and ‘William’s. This study helps to understand the role of polyphenol oxidase (PPO) and peroxidase (POD) as two of the major enzymes involving in enzymatic browning in banana peel and pulp tissue.

11:30 AM – 11:45 AM

**GC-O, Volatile and Qualitative Differences in Locally Grown Rabbiteye and Southern Highbush Blueberries, and Juices**

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Southern and southeastern U.S. production of blueberries has increased markedly in recent years. Gas chromatography-olfactometry (GC-O) and volatile and semi-volatile compounds are seldom reported in rabbiteye blueberry (RAB). Few comparisons have been made between the organoleptic differences between RAB and southern highbush (SHB) fruits and pressed juices therefrom. We performed GC-O, GC-MS, volatile and physiological quality appraisals in six varieties of SHB and RAB harvested twice in a single season. Three varieties of RAB (Alapaha, Columbus, and Montgomery) and three varieties of SHB (Biloxi, Magnolia, and Misty) blueberries were hand harvested fully ripe, 10 days apart in Poplarville, MS. Fruit were either sampled fresh after hydraulic pressing in a small Ferrari press with nylon-mesh to mimic steps toward making a mash and juices, or frozen immediately after harvest, and pressed after thawing via muslin cloth. Commercially frozen RAB (‘Tifblue’) heated mash was enzyme-treated, hydraulically pressed, not filtered and ultrafiltered, and pasteurized juices prepared in our pilot plant for a comparison. Samples were assessed for rapid qualitative differences (pH, brix, titratable acidity, color). The SPME carboxen/DVB/PDMS fiber absorption on a fully automated Gerstel MPS2 was followed by splitting the run into an Agilent 7890-A Gas Chromatography (GC) FID with a BreckBühler Sniffer9000 GC-O (Olfactometer). Volatiles were confirmed separately via identical runs on an Agilent 6890/5973 GC-MS. Freshly pressed berry juice had higher L*, a*, b* and C* but lower hue angles than juices prepared from frozen berries, and similar values compared to pasteurized samples. On the other hand the freshly pressed juices had markedly lower titratable acidity and conversely higher soluble solid:acid ratios compared with frozen pressed samples. Volatiles such as (Z)-3-hexen-1-ol, (E)-geraniol, linalool, linalool oxide, eugenol and β-damascone were identified and assessed, and compared against sample aromas and known standard compounds. ‘Alapaha’ contained potent aromas of alcohol, chocolate, blueberry, grass, sweet, fruity, floral, and spice. ‘Montgomery’ had aromas of blueberry, chocolate, fruit, cinnamon, coffee, and alcohol. ‘Magnolia’ was very fragrant, perfume-like juice. The other varieties did not exhibit such potent and distinct odors but, had faint blueberry, sweet, coffee beans, fruity, floral, heated plastic and iron notes. Specific compounds such as (E)-geranyl acetone, linalool oxide, β-pinene and camphene had matching GC-O, RT and MS confirmations, and these are compounds that are important or possibly important in fruit aroma (e.g. blueberry, sweet, green flower, fruity and floral notes). Berry and juice differences along with volatile and aroma nuances and findings will be explored further.

*Specified Source(s) of Funding: U.S. Government*
Influence of Tree Position on Free Non-Polar Cuticular Metabolites of ‘d’Anjou’ Pear during Controlled Atmosphere Storage

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Tree position, especially in larger canopies, can impact fruit maturity, ripeness, and quality potentially influencing every management decision throughout the cold chain. Our earlier reports reveal the extent to which metabolism is altered including areas as diverse as those directly associated with fruit quality, aroma, appearance, and cellular integrity at harvest and throughout storage. The current report focuses on a relatively novel group of freely extractable metabolites including hydroxycinnamoyl triterpenes (coumaryl triterpenes) as well as fatty acyl esters of hydroxyfarnesene (hydroxyfarnesene esters), hydroxyxinnamoyl alcohols (p-coumaryl esters), and ursolic acid (ursolic esters). (7E,9E)-2,6,10-Trimethyl-2,7,9,11-dodecatetraen-6-ol (CTOL) and detected 16:0, 18:0, 18:1, and 18:2 CTOL esters were composed of 3 different hydroxyfarnesene head groups. Fatty acyl moieties p-coumaryl, ursolic, and amyrin esters ranged from 16:0 to 22:0. CTOL, hydroxyfarnesene esters, p-coumaryl, and ursolic esters were elevated in peel of external fruit. CTOL and 2 hydroxyfarnesene esters were only detectable beyond 3 months in storage and p-coumaryl and ursolic esters were detectable at harvest. Both classes increased with storage duration. Coumaryl triterpenes were higher in peel from internal fruit at harvest and did not increase with storage duration. The function of these metabolites is largely unknown but are thought to be primarily structural or functional as specialized monomers of cutin with potential antioxidative functions or even providing polar paths through the cuticle. However, the outcome of these differences may be as evident as fruit appearance where superficial scald only developed on external fruit and CTOL and hydroxyfarnesene ester levels were highest. These results warrant further study of conditions leading to metabolic differences and the impacts they may have on fruit quality.

Specified Source(s) of Funding: Washington Tree Fruit Research Commission

Commercial Horticulture 3

Moderator: Yan Chen
Louisiana State University Agriculture Center & Research Station, Hammond, LA, USA

10:45 AM – 11:00 AM

Louisiana Tea Consumer Survey and Willingness-to-pay for U.S.-grown Tea

Yan Chen*
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United States (U.S.) tea consumption reached $12 billion in 2016, and is projected to have a 6% to 10% annual increase over the next ten years. Consumers are increasingly interested in where tea is sourced and whether or not it was produced in an environmentally and socially sustainable manner. The “grow-local” movement in recent years also provides an opportunity for U.S. growers and investors to consider this traditional Asian crop as a new specialty crop. This survey was conducted with more than 200 Master Gardeners, and focused on purchasing preference and willingness-to-pay for tea products grown and processed domestically. Results indicated that about 92% of survey participant drink tea, and retail stores and super markets (84%) are major places for purchasing tea products, followed by consumption at restaurants (48%). Tea bags are still the most popular tea products (82%) followed by ready-to-drink bottled tea (36%). About 19% of participants purchased loose tea in the past 6 months which is encouraging because currently loose tea is the most profitable type of product for U.S. tea growers. Compared with hot tea, especially those prepared from loose leaf, iced tea is still the most popular form in tea consumption, especially during the summer. For this specific age group, motivations for drinking tea are (by ranking): “it tastes good”, “health benefits”, and “relaxation”, and the top three factors affecting purchasing decisions were (by ranking) quality, availability, and cost. About 27% of participants prefer purchasing tea grown and processed locally or domestically, while 70% said origin does not affect purchasing decision. About 39% of participants preferred tea grown with sustainable production practices, while only 22% would like to purchase tea products that are organically grown. Assuming similar quality, about 54% of participants would pay the same price for domestically grown tea as they would for imported tea, and the rest would like to pay 10% to 20% more for domestically grown tea. These results indicate that there is a market demand for domestically grown tea and the demand is likely to increase when U.S.-grown tea becoming more available.

Specified Source(s) of Funding: Louisiana State Department of Agriculture and Forestry
Tea As an Alternative Crop for Mississippi

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Eugene Blythe
Mississippi State University Coastal Research and Extension Center, Poplarville, MS, USA

Qianwen Zhang
Mississippi State University, Mississippi State, MS, USA

Tongyin Li
Mississippi State University, Mississippi State, MS, USA

Tea is second only to water as the most popular beverage in the world. In 2017, over 84 billion servings were sold in the United States (U.S.), with projected sales to double over the next 10 years. Nearly all the tea sold in the U.S. is imported, making the U.S. the third largest tea importer in the world. The promising market trend and increasing consumer demand in locally grown products have promoted growers’ interest in domestic tea production. *Camellia sinensis*, the source for tea leaves, is an evergreen shrub grown in tropical and subtropical regions. The soil and climate in Mississippi is suitable for growing tea. While tea has been grown in other countries for centuries, there is limited tea production in the U.S. and little research-based information to guide U.S. farmers on tea production. A series of experiments were conducted to evaluate tea cultivar performance and identify best management practices for tea production. Preliminary results showed that tea cultivars vary in leaf size, color, growth habit, vigor, and heat and cold tolerance. Providing plants with shade after transplanting into the field improves plant survival rate, especially when irrigation is limited. Transplanting during February and March improves plant survival rate. Mulching a newly planted tea field with pine bark, pine straw, and wheat straw effectively controls weeds and improves plant growth.

Specified Source(s) of Funding: USDA Specialty Crop Block Grant Program

Growing Tea As a Cash Crop in the Southeastern United States

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Yan Chen
Louisiana State University Agriculture Center & Research Station, Hammond, LA, USA

Jason W. Stagg
Louisiana State University Agricultural Center, Hammond, LA, USA

Tea, *Camellia sinensis* (L.) Kuntze, is a native plant to China with more than 3000 years of cultivation. Although it has been grown here in the continental United States (U.S.), for some reasons, perhaps the cost of processing, the cost of cultivation,
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

11:45 AM – 12:00 PM

In-ground Vegetative Propagation of Single Node Tea (Camellia sinensis) Cuttings

John Ruter*
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The relative merits of different propagation techniques of tea (Camellia sinensis (L.) Kuntze) were investigated. Single node cuttings of three cultivars of two varieties (var. assamica and var. sinensis) of the tea plant were rooted separately in raised beds of native Cecil clay-loam soil, or in a layer of sand laid on flat ground, in shaded low tunnels outdoors with mist nozzles. Percentage of rooted propagules were recorded and rooted plants were evaluated 18 weeks after sticking for root dry weight and root length measurements. Cuttings propagated with a sand substrate on flat ground had higher rooting percentages (85%) than cuttings placed in native soil (78%). Cultivar had no influence on percent rooting. Root length was influenced by substrate and cultivar. Root dry weight was affected by an interaction between substrate and cultivar. Rooting plants in the ground may be a good alternative to traditional container propagation systems.

12:00 PM – 12:15 PM

Coffee (Coffea arabica): A New Crop for Southern California?

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Christopher Van Norden
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Keith Kittredge
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Coffee ranks second only to oil as the most important commodity in world trade and is the primary agricultural export for many countries. Coffee (Coffea spp.) is native to Africa where an estimated 100 species are found in diverse geographic and climatic regions. Coffee species vary greatly depending on the region and climate of their origin, resulting in various coffee types with different genetic make-ups, different morphological traits (size and shape of plants, fruits, and growing habits), flavor profiles, tolerance to pests and diseases, and tolerance to drought. Coffee plants adapt and grow well in frost-free microclimates in California from San Luis Obispo to San Diego County. Specialty coffee consumption and the demand for specialty coffees have increased dramatically in the United States and the world over the past several years. This trend, combined with increased demand for high value, differentiated agricultural products (local or California grown) and declining profit margins for existing crops, has generated a strong interest in the production of specialty coffee among farmers in Southern California and in coffee as an ornamental, household plant. Replicated field trials using a randomized complete-block design were established at two different geographic locations in Southern California to evaluate the adaptation and performance of a selected number of coffee varieties: 1) an organic trial, under full sun, in monoculture was established at Cal Poly Pomona; and 2) a conventional trial, under shade, in association with cherimoyas was established at the University of California South Coast Research and Extension Center (UC-SCREC) in Irvine, CA. In addition, observation/demonstration trials were established under conventional production systems and in full sun at UC-SCREC in Irvine and in collaboration with several Master Gardener volunteers across Southern California. Preliminary results indicate that coffee grows/adapts very well to growing conditions of select microclimates in the region and could be successfully grown to bear fruit. However, the results also showed that coffee is highly susceptible to extreme weather conditions (strong winds and hot and cold temperatures) and site selection and plant protection are critical for successful establishment and production. This poster/presentation will help illustrate all phases for coffee production from seedbeds to field establishment, summarize results and observations to date and discuss future plans.
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

S220

Grafting Increases Yield of Watermelon in a Cold Climate
Rob Brown
Flattop Farm, Anchorage, AK, USA
Ed Scheenstra
Washington State University, NWREC, Mount Vernon, WA, USA
Carol Miles*
Washington State University, NWREC, Mount Vernon, WA, USA

In Alaska, more than 95% of the $2 billion spent on food purchases each year is imported via boat or plane, and grocery stores have a maximum of two weeks supply. Prices for fresh produce are very high in rural communities, and this limits consumption. Climate modifying structures such as high tunnels can enable growers to produce fruits and vegetables locally, and the USDA estimates it has awarded $4 million in contracts and grants for high tunnels in Alaska. High tunnels in Alaska require extra construction considerations to withstand heavy snow loads (10 ft at Flattop Farm, the site of this experiment in Anchorage) and deep ground freezing. Additionally, crops such as watermelon require additional strategies for successful production. We grafted two watermelon cultivars, Blacktail Mountain and Marmaladny, on Tetsukabuto rootstock and evaluated fruit production. Seeding was 10 June 2017, and grafting was with the hole-insertion method on 17 June 2017. This was the third planting as the first and second plantings were lost due to seed-borne disease on cultivars that were locally sourced and that spread to experimental plants. Seedling production, grafting, and hardening were in grow rooms in the house basement, with fluorescent or halide grow lights and temperature maintained at 75 to 83 °F. Grafted plants were healed for 9 days in a grow tent (50 in. × 50 in. × 79 in.), also inside the house; an ultrasonic humidifier and humidistat provided 90% relative humidity, temperature was 74 to 75 °F, and lighting was a fluorescent grow tube. Transplanting into high tunnel was on 29 June. The experimental design was a randomized complete block with six plants per plot. Raised beds were covered with IRT olive-colored mulch (1 mil). Plants were hand pollinated within a cultivar. Soil temperature in the plots was 60 °F on 24 Aug. Fruit were harvested on 28 Sept., and all fruit were immature (TSS 5 to 6%). Grafted Marmaladny produced almost two times the number of fruit and three times the total fruit weight per plot than grafted Blacktail Mountain, and four times the number of fruit and nine times the total fruit weight than grafted Blacktail Mountain and non-grafted Marmaladny (P < 0.0001). Average weight per fruit was 5.73 lb for grafted Marmaladny, which was 1.7 times greater than other entries (P = 0.02). Grafting of watermelon increased fruit production with cold soil temperature in southcentral Alaska. The experiment will be repeated in 2018.

Specified Source(s) of Funding: Western Sustainable Agriculture Research & Education

Effect of Irrigation and Plastic Mulches on Verticillium Wilt Severity of Rootstock for Watermelon Grafting
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Yorav Dave Klawer
Washington State University, Mount Vernon, WA, USA

Verticillium wilt, caused by Verticillium dahliae, is a destructive soilborne disease that limits watermelon production worldwide. Control of this disease is becoming challenging for watermelon producers in Washington state due to the widespread distribution of the pathogen, the persistence of its microsclerotia in soil for many years, and phase-out of soil fumigants such as methyl bromide. Grafting watermelon onto resistant rootstock represents a promising disease management strategy, but there is little information regarding rootstock resistance to verticillium wilt. Evaluating rootstocks for resistance to V. dahliae is the first step in developing a management strategy for controlling this pathogen via the use of grafted plants. This study investigated the reactions of seven commercially available rootstocks, ‘Tetsukabuto’, ‘Super Shintosa’, ‘Java’, ‘Flexifort’, ‘Shintosa Camelforce’, ‘Cobalt’ and ‘Carnivor’, and seedless watermelon ‘Fascination’ (verticillium wilt-susceptible control) to V. dahliae in a naturally infested field (5 cfu/g of soil) at Washington State University Northwestern Washington Research and Extension Center. To evaluate the disease severity in combination with crop management, we tested black and clear plastic mulch, and two irrigation treatments, management allowance depletion (MAD) water application vs. scheduled water applications through drip irrigation. The irrigation time difference between scheduled and MAD treatment was 30–40 minutes per irrigation application, and overall, 33% less water was applied in MAD treatment compared to scheduled treatment. Area under disease progress curve (AUDPC) values did not differ significantly due to irrigation treatment or mulch treatment. The overall AUDPC value for verticillium wilt was higher for non-grafted watermelon than for the seven rootstock treatments (P = 0.0006). Results indicate that verticillium wilt severity was greater for ‘Fascination’ than for the seven rootstock treatments at the end of the growing season, but irrigation treatment and type of plastic mulch did not significantly effect on the disease severity in this study.

Specified Source(s) of Funding: USDA-ARS project #2012-51160-19645

An asterisk (*) following a name indicates the presenting author.
**Development of Photosynthetic Models of Kimchi Cabbages Incorporating CO₂ Concentration and Plant Growth Stage under Extreme Weather**

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The aim of this study was to develop the photosynthetic models of Kimchi cabbages under the abnormal temperatures at the different growth stages for evaluation of the net photosynthetic rate. The Kimchi cabbage plants were applied to the extreme high temperatures (25/22, 30/27, 35/31 °C; photo-/dark periods) at 7–10 days after transplanting (DAT) and 40–43 DAT using the extreme weather simulators. Except for these periods, the environments in terms of air temperature, relative humidity, radiation, and precipitation were set by the previous meteorological data (mean of Sept.–Nov. 2014–16, Haenam, Republic of Korea). The photosynthetic CO₂ response curves (An-Ci) were measured at 16, 29, 43, 59, and 70 DAT using a portable gas exchange system. An-Ci data were used to calculate three biochemical parameters in terms of photochemical efficiency, carboxylation conductance, and dark respiration at each measuring date. Those were used to develop the photosynthetic models, modified Thornley’s model, representing the prediction of net photosynthetic rate by CO₂ concentration and growth stages. The simulated net photosynthetic rates (s-An) differed as affected by extreme weather events, the s-An with extreme high temperature treatment (35/31 °C) was 19.7 µmol·m⁻²·s⁻¹ which was evaluated approximately 3% deduction compared with control. Results indicated that developed photosynthetic models might be applied to evaluate retard growth and the net photosynthetic rate under abnormal temperature conditions.

**Specified Source(s) of Funding:** This work was carried out with the support of the “Cooperative Research Program for Agriculture, Science & Technology (Project No. PJ 01196501)”, RDA

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**Effect of Growing Systems on the Production of Specialty Cantaloupes (Cucumis melo L.) in Indiana**

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Daniel S. Egel  
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Amanda J. Deering  
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Over the past two decades, the planted acreage of Indiana fresh market cantaloupe has declined by 50%. Increased competition from neighboring states and higher production risks due to food safety related issues have contributed to the decline along with growing conditions that limit production to a small selection of cantaloupe types. The decrease in acreage and market share is a threat to the long-term sustainability of the cantaloupe industry in Indiana. Improved production technologies may change this situation. The production of a more diverse range of cantaloupe types (i.e. Charentais) and the use of production technologies that would increase yield and enhance product quality could increase the current market share of Indiana fresh cantaloupe. Charentais is a popular melon in France. They are fragrant with high sugar content. North American type cantaloupes (C. melo var. reticulatus) and Charentais (C. melo var. cantalupensis) were grown as a spring/summer crop to determine the effect of growing systems on yield and fruit quality. During 2017, eight specialty cantaloupe cultivars were grown in a conventional open field production system and in two passively ventilated high tunnels at the Throckmorton and Southwest Purdue University Agricultural Centers in Lafayette and Vincennes IN, respectively. In one high tunnel, cantaloupes were grown in a soilless growing media using hydroponic production techniques, and in the other they were planted in soil. Mean fruit number per plant varied between the different cultivars, but a consistent trend was observed between the different production systems. All cultivars produced between 3 and 6.3 fruit per plant, except Savor, which produced significantly lower yields in the open field and soil-grown high tunnel. Average fruit weight was consistent between production systems, except for Inspire and Escorial, which produced significantly larger fruit in the open field evaluation. Tasty Bites and Inspire produced a significantly higher total fruit weight per plant in the open field and soil-grown high tunnel evaluation. Yields varied between 5.7 and 7.1 kg per plant. However, yields were significantly higher in the high tunnel production systems compared to the open field. This is mainly due to the 3.2 times higher planting density in the high tunnels. Mean TSS was 10.6 °Brix or greater in the...
open field evaluation. Cultivars in both high tunnel growing systems produced fruit with lower TSS compared to the open field. High tunnels produce significantly higher yields, but fruit quality will need to be improved. 

*Specified Source(s) of Funding:* Purdue University AgSEED Grant

**Oral Presentations**

**Effects of Bacteria and Methylamine on Yield and Plant Growth of Squash under Water Stress**

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**İbrahim Demir**

Ankara University, Ankara, Turkey

In this study, we investigated the effects of bacteria and methylamine on fruit yield and plant growth of squash (Cucurbita pepo L. cv. Sakız) under different irrigations levels. For this purpose; three bacteria strains (Bacillus megaterium TV-91C, Bacillus megaterium TV-6D, Bacillus subtilis RK-1900), the product of methylamine (MA), and a control (no bacteria+MA) were used as treatments. Four irrigation levels (Full-irrigation; 100%, 85% of the full-irrigation, 70% of the full-irrigation, and 55% of the full-irrigation) were applied to plants in the field. The effect of treatments on parameters such as yield per plant, fruit number, fruit weight, fruit diameter, fruit size, leaf chlorophyll reading value, fruit TSS, vitamin C, and fruit dry matter was statistically significant. In particular, drought stress significantly reduced these parameters. However, these reductions were lower with bacteria+MA applications. In severe drought stress conditions, generally better results were obtained with TV6D+MA application for fruit number, fruit yield, fruit weight, fruit length, plant dry weight, and chlorophyll reading value. On the other hand, RK1900+MA application increased fruit diameter, vitamin C, and fruit dry matter under severe drought stress. Plant fresh weight, stem diameter, and leaf number were increased with TV91C+MA application under severe drought compared to other applications. With full irrigation, TV6D+MA and RK1900+MA applications showed the greatest increase in fresh and dry weights as compared to the control treatment. We have observed that the negative effect of drought stress on the growth and fruit of squash was more affordable with the application of bacteria+MA as compared to the control. This research reveals that application of bacteria together with MA enhances tolerance capability against drought stress, and they can be used for reducing the deleterious effects of drought conditions on yield and growth of squash as an eco-friendly approach.

*Specified Source(s) of Funding:* TÜBİTAK

**Controlling Powdery Mildew on Cucurbit Crops through Biological Control Agents**

**Nia Gordon**

Tennessee State University, Nashville, TN, USA

Cucumber and squash are cucurbits that have nutritional and medicinal benefits. These two crops contain essential provitamins, vitamins, and minerals such as potassium, iron, calcium, magnesium, manganese, copper, phosphorous, and calcium. In Tennessee, these cucurbit crops are affected by several major infectious diseases including anthracnose, Cercospora leaf spot, cucumber mosaic, downy mildew, Phytophthora fruit and crown rot, Septoria leaf spot, squash mosaic, Verticillium wilt, and powdery mildew which severely reduce their productivity. Powdery mildew is ranked as the most severe disease of these cucurbits. Symptoms of powdery mildew appear as a white powdery residue on the upper leaf surface with circular patches or spots. Infected leaves become brown and shriveled and defoliate prematurely and infected fruits remain small and do not develop fully. Thus, the yield is reduced due to a decrease in the size or number of fruits and/or a decrease in the length of the harvest period. The purpose of this study is to control/treat powdery mildew in cucumber and squash using Biological Control Agents (BCAs). BCAs are known to reduce disease incidence directly or indirectly by inhibiting the development and activities of pathogens and/or promoting plant growth. The BCA mechanisms of actions include direct antagonism of the pathogens by selectively attacking pathogens through hyper-parasitism, production of antibiotics and/or lytic enzymes, competition for space and food source, and by inducing systemic resistance in the host plants. Our study focuses on evaluating the effect of five previously isolated BCAs in controlling powdery mildew using weekly foliar sprays on cucumber and squash plants. Our preliminary results show a decrease in powdery mildew disease severity after four BCA applications. Extensive analysis of plant growth response to BCA applications is in progress.

*Specified Source(s) of Funding:* Office of Outreach and Advocacy-USDA
Computer Applications in Horticulture/Ornamental Breeding

Moderator: Tomas Hasing
Virginia Tech, Blacksburg, VA, USA

2:00 PM – 2:15 PM

Using Interactive 3D Models Generated By R/Plotly to Answer Questions within a Breeding Program

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Basic questions such as: disease variation in a field, disease progression throughout the season, effect of nearby covariates, and the progression of desirable genotypes, are normally answered by analyzing the data through statistical software such as SAS, JMP, SPSS, or R. However, it is often the case that searching through the long outputs of these programs for one or two p-values is less informative and harder to comprehend than a basic R-script utilizing R/plotly to visualize the data. We investigated the use of interactive 3D plots generated by R/plotly to answer the following important inquiries: Which genotypes to use as parents in this year’s crosses based on best performance in our environment throughout the year. Whether the distribution of flower yield or disease incidence was affected by the presence of a dirt road running by one side of the field or by partial flooding of the field due to Hurricane Harvey. Outputs are interactive and can help identify outliers and specific individuals in large datasets without having to search for specific values within spreadsheets with thousands of rows.

Specified Source(s) of Funding: “Combating Rose Rosette Disease: Short Term and Long Term Approaches” (2014-51181-22644/SCRI).

2:15 PM – 2:30 PM

The Polyploidization of Novel Poinsettia ‘Dulce Rosa’

Ya-Fen Lu
National Chung Hsing University, Taichung City, Taiwan

Yen-Ming Chen*
National Chung Hsing University, Taichung City, Taiwan

Poinsettia is one of important pot flower crops in the world. In recent years, interspecific hybridization is adopted to introduce new plant character of Poinsettia. In 2003 US company Ecke created ‘Dulce Rosa’, novel interspecific hybrid conducted by the pollination between Euphorbia pulcherrima and E. corn-astra. However the pollen sterility of ‘Dulce Rosa’ prevents it from being material for continuous breeding work. The main purpose of present research was to restore its fertility by polyploid mutagenesis. The in-vitro internode explants of ‘Dulce Rosa’ were cultured on artificial medium which contains colchicine for mutation treatment. The survival mutants evaluated the plant characteristics and pollen fertility, as well as the relative DNA content also confirmed by flow cytometry to compare the differences. The results indicated that ‘Dulce Rosa’ bract color being RHS-57D, the bract color of mutant significantly darkened (RHS-57B&57C). In addition, the blade aspect ratio of ‘Dulce Rosa’ being 2.37, but the mutant’s blade is widened (aspect ratio 1.71), as well as thickened leaf and increased hair villus amount. The width and length of mutant’s guard cell is increased 1.3 times. In addition, the lack of stamen due to ‘Dulce Rosa’ flower abnormality, the mutant with functional reproductive organs, and the anther stretches from involucrum and releases fertility pollen after colchicine induction treatment. Under optical microscope, mutant’s pollen characteristic turns normal without wrinkling. The M2 mutant has highest pollen germination rate and its pollen tube germinates well in BK medium (20% sucrose). The DNA content of mutant is twice as many as those of ‘Dulce Rosa’, proving the evidence of colchicine mutant being polyploidy.

2:30 PM – 2:45 PM

Assessing Genetic Compatibility within and Among Asclepius Spp. and Creation of Novel Cultivars for the Floriculture Market

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Asclepias is an important ecologic host and food source for many butterfly species that utilize nectar and foliage as a food source. It is also known for its attractive floral structures and performance in landscape environments with minimal fertilizer and irrigation inputs. Despite having ornamentally and ecologically valuable traits, cultivars of Asclepias spp. are not commonly found in the ornamental market as Asclepias spp. does not tolerate commercial growing protocols that incorporate high fertility and irrigation rates, and as a result grow to heights too large for efficient racking and shipping or suffer from pathogens. Another major challenge in developing hybrid cultivars is that hybrid fertilized embryos often undergo late-term abortion. This has deterred many ornamental breeding programs from attempting interspecific crosses within the genus. In this project, Asclepias tuberosa was used as the female parent, as this species is the most widely-grown taxa and possessed many traits superior to other species in the genus. The pollen donors were Asclepias speciosa, A. syriaca, A. viridis, A. incarnata, A. purpurascens,
Genomic Analysis of the Domestication of Sinningia speciosa

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Sinningia speciosa (Gesneriaceae) is a perennial, herbaceous flowering plant native to the Atlantic Coastal Forests of Brazil. After the species was introduced into England in 1815 its cultivation as an ornamental house plant developed quickly. Within only a few short years it gained popularity across London and soon after specimens reached several parts of the world, including the United States. Modern cultivars exhibit a broad range of phenotypes. Their large, colorful, upright, bell-shaped (actinomorphic) flowers differ markedly from the smaller, lavender, nodding (zygomorphic) flowers commonly found in the wild forms. Given its short history of cultivation, S. speciosa can serve as a model to understand the significant genomic changes that are associated with the process of plant domestication. The genome of the wild accession ‘Avenida Niemeyer’ (~400 Mb) was sequenced and assembled (PacBio corrected with Illumina reads) as a reference for subsequent alignments. A collection of 128 individuals within the tribe Sinningieae was genotyped using the Genotyping by Sequencing (GBS) method. Sixty-two individuals were S. speciosa (41 commercial cultivars and 21 wild accessions) and the remaining 66 represented 35 species sampled across the tribe. We retained 9913 high quality non-missing SNPs across all species, and 25,083 within S. speciosa. Additionally, we phenotyped and genotyped (GBS) 160 individuals from an F₂ population derived from the cross of ‘Buzios’ (wild) by ‘Empress’ (cultivar). Principal component analysis on genetic distances clustered all the species according to the three major clades in the tribe: Sinningia, Corytholoma, and Dircaea. Cultivated and wild accessions of S. speciosa clustered together with no signs of interspecific hybridization events driving the process of domestication. We also detected a reduction of between 40 and 58% in genetic diversity across the cultivars relative to their wild counterparts. This bottleneck is likely the result of the limited number of individuals originally brought into cultivation (founder effect). In fact, distance clustering and ADMIXTURE analysis revealed only two wild accessions in the background of cultivated material: ‘Avenida Niemeyer’ and ‘Antonio Dias’. Quantitative Trait Loci analysis of flower symmetry (actinomorphic vs. zygomorphic) and flower color (purple vs. red) revealed highly significant single loci for each trait. Under the QTL responsible for flower symmetry we located a CYCLOIDEA-Like (CYC) gene with two small deletions that correlate with the trait. CYC encodes a transcription factor that controls floral symmetry in the snapdragon (Antirrhium majus).

2:45 PM – 3:00 PM

Comparison of Linkage Maps for Diploid Rosa

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Although roses are the backbone of the ornamental plant industry, genetic studies in roses have been complicated by the lack of an available rose genome sequence. However, with the release of the Rosa chinensis sequence, new opportunities have arisen for rose genetics and breeding. Prior to the release of the diploid rose genome, we genotyped 15 inter-related diploid rose populations using genotype by sequencing (GBS) for single nucleotide polymorphisms (SNPs) using the Fragaria vesca genome as a reference and created an integrated consensus map for use in quantitative trait locus (QTL) discovery. This resulted in the discovery of 40-50,000 SNPs over 15 populations with about 3500 determined to be useful for the integrated consensus map created via JoinMap 4.1. To determine if the map could be improved after the release of the rose genome, the GBS reads
were aligned with the rose genome and SNPs were called. This resulted in approximately 60-80,000 SNPs (depending on the family), which is significantly greater than the number of SNPs called when the \textit{Fragaria} genome was used as a reference. These SNP calls were filtered and used to make a new integrated consensus map via JoinMap 5. The two maps were compared on the criteria of marker number, map length, mean distance between markers, and the largest distance between markers.

Specified Source(s) of Funding: USDA-SCRI, “Combating Rose Rosette Disease: Short Term and Long Term Approaches” (2014-51181-22644/SCRI)

Zebra chip is a disease of potatoes caused by a bacterium (\textit{Candidatus Liberibacter solanacearum}) that is vectored by a tiny insect, the potato psyllid (\textit{Bactericera cockerelli}). Plants infected with zebra chip die early and produce tubers with an internal necrotic defect. The disease, which was known to occur in other parts of the United States for more than a decade, was not found in the Columbia Basin of Washington until 2011. This initial outbreak resulted in the complete destruction of at least two potato fields and symptomatic tubers were reported from several more fields in the region—the losses were estimated at over a million dollars. In 2012, potato psyllids were added to our regional insect monitoring program (established in 2009 to monitor aphids, beet leafhoppers, and potato tubeworm). After some trial and error, we determined that a combination of yellow sticky cards and leaf samples was the best way to monitor potato psyllids. The most important output from the monitoring program is a weekly e-newsletter, called \textit{WSU Potato Pest Alerts}, that includes reports about the current prevalence and distribution of potato psyllids, scouting instructions, and management recommendations. This information assists growers in making informed and timely management decisions and may explain why zebra chip has been seen in the Columbia Basin since 2011, but has not resulted in significant losses. The monitoring program also helps us learn more about psyllid biology and behavior. It has revealed details about psyllid migration and distribution in the region, and has led to the discovery of some important overwintering hosts. We have also documented some very large swings in the size of psyllid populations each year; almost 30,000 psyllids were collected in 2016 compared to only 152 psyllids in 2017 using the same number of traps. The infection rate of psyllids has been less varied, with Liberibacter detected in only 0.00% to 0.17% (average 0.14%) of the psyllids each year. These percentages are smaller and less varied compared to the infection rate of psyllids in Idaho during the same period. The low infection rate of psyllids in Washington means that our monitoring and testing program has not been able to predict exactly when and where isolated incidences of zebra chip will occur. But, in the future we will know to anticipate zebra chip if the monitoring program collects unusually large numbers of psyllids or detects a larger proportion of psyllids carrying Liberibacter.

Specified Source(s) of Funding: The Washington State Potato Commission, USDA Technical Assistance for Specialty Crops (TASC), and USDA-ARS-State Partnership Potato, Program

The yellowmargined leaf beetle (YMLB) is a major insect pest of \textit{Brassicas} across the southeast and has increased in occurrence in Alabama where crop devastation can easily exceed 50%. YMLB is native to South America and it was first detected in Mobile, USA, in 1947. Two researchers at Auburn University (R. Balusu and H. Fadamiro) along with collaborators at the University of Florida (O. Liburd) initiated a YMLB research projects in 2010 that gradually added an educational component with Alabama Extension Commercial Horticulture Program to rapidly disseminate pest alerts and management information. With increasing number of small farms growing winter crops in Alabama, the threat of YMLB has also increased significantly since 2010 with many reports of crop failure and produce contamination. At present, organic insecticides alone do not provide adequate crop protection due to strong migration pattern and rapid build up of YMLB. Adults and larvae of YMLB can defoliate turnips and Napa cabbage in a few days followed by movement to other brassica crop or weedy hosts. Since YMLB is strongly attracted to turnips, it can be used as a trap crop in conjunction with biorational insecticides to become a true integrated pest management (IPM) strategy. Based on small-plot research, the extension IPM team developed large-scale trap crop test plots that serve as demonstration areas for grower education. Based on multi-year studies, there is evidence that two to four rows of early-planted turnips as a perimeter trap

An asterisk (*) following a name indicates the presenting author.
Tomato Accessions Affect Aphid Performance and Feeding Behavior

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Piercing-sucking insects such as aphids pose a serious problem in the commercial production of horticultural crops including tomato, since damage is caused not only by direct feeding, but also by transmission of viruses for which these herbivores serve as vectors. Current control strategies involving synthetic insecticides are increasingly considered as problematic due to emerging resistances, costs for growers, and concerns of consumers, highlighting the need to develop new efficient and sustainable approaches to control these pests. Recent studies of terpene production in glandular trichomes of tomato plants, found on their leaves and stems, and known to be involved in plant-insect interactions, demonstrated significant differences between cultivated and wild tomato species, as well as quantitative and qualitative variation among wild tomato accessions. Since these wild tomato accessions potentially represent good sources of defensive traits against aphids, we have performed a number of assays to compare the performance and feeding behavior of the potato aphid, Macrosiphum euphorbiae, on leaves of cultivated tomato (Solanum lycopersicum) and multiple wild tomato accessions (Solanum habrochaites) representing different terpene chemotypes. Non-choice assays demonstrated that longevity and fecundity of potato aphids was significantly lower on two groups of S. habrochaites accessions compared to S. lycopersicum. Subsequently, we analyzed aphid feeding on an artificial medium containing either leaf extracts with glandular trichome derived terpenes from cultivated and wild tomato accessions, or pure terpene compounds. Our analysis of aphid survival, as well as accumulation of salivary sheath and honeydew production, both indicators of aphid feeding, suggest that selected glandular trichome derived terpenes found in some S. habrochaites accessions influence aphid performance by affecting their feeding behavior. In addition, we performed olfactometer choice assays to study the effect of terpenes emitted from different tomato accessions on the search behavior of winged potato aphids toward host plants. The same S. habrochaites accessions that showed significant effects in the previous non-choice and feeding assays, were also found to be repellent toward winged aphids. Moreover, addition of leaf extracts of these S. habrochaites accessions or respective pure terpene compounds to leaves of cultivated tomato plants significantly reduced the attractiveness of these to aphids. The identification of several terpenes from S. habrochaites accessions with the potential to affect the overall performance, feeding, and search behavior of potato aphids no allows us to introduce these defensive traits into cultivated tomato by introgression and metabolic engineering.

2:30 PM – 2:45 PM

Glandular Trichome-derived Terpenes of Wild Tomato Accessions Affect Aphid Performance and Feeding Behavior

2:45 PM – 3:00 PM

Parasitoid Surveys in Cycad Habitats on Guam

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Scale-infested cycad leaves were sampled on the island of Guam in a wide range of habitats in 2017 and 2018 to determine the extent of parasitoid control of the scale. The sampling unit was a leaflet selected from five trees per habitat during each sampling date. The number of scales were counted with a hand lens and parasitoids were reared in a growth chamber at 60% relative humidity. Infested leaflets were transferred to new rearing vessels after 48 hour intervals and returned to the growth chamber. Insects were rinsed with 70% EtOH and parasitoids were counted with the aid of a microscope. The abaxial leaflet surfaces harbored greater numbers of scale than the adaxial surfaces. In a Northern Guam site where parasitoids were first fortuitously discovered in 2013, only 20% of the samples yielded parasitoids. For each geographic site, the presence of parasitoids on one sampling date did not always lead to evidence of parasitoids at a later sampling date. The number of parasitized scales was minimal despite the widespread geographic occurrence of the parasitoids. Several native and exotic Cycas cycad species were historically heavily used in the commercial and residential landscapes of Guam, and the recent invasion of the cycad Aulacaspis scale (CAS) Aulacaspis yasumatsui Takagi has devastated these cycad populations. These results

An asterisk (*) following a name indicates the presenting author.
provide the first evidence that scale parasitoids are established throughout most of the island, but they are not effectively controlling the scale infestations. This case study is an example of how the horticulture profession can aid in responding to an ecological disaster.

3:00 PM – 3:15 PM

**Potential of Nanotechnology in Horticulture**

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Nanotechnology is an emerging branch of science with an enormous potential to manage plant pests and pathogens. Our current work on soybean looper (Chrysodeixis includens (Walker)), beet armyworm (Spodoptera exigua (Hübner)), Japanese beetle (Popillia japonica (Newman)), cucumber beetle (Diabrotica undecimpunctata howardi (Barber)), and Fusarium Head Blight (Fusarium graminearum) using nanoparticles (nano-clay (NC); 200–700 nm, nano-zinc-oxide (NZO); 20–50 nm, and nano-sulfur (NS); 20–60 nm) showed promising results. Three independent experiments (2017) were conducted in a randomized complete block design with ten blocks, and one plant of each treatment per block in the field conditions. Ten plants were used for each treatment. The means per plant was determined and subjected to analysis of variance (SAS Institute, Cary, NC) and separated using a protected least significant difference (LSD) at P < 0.05. Similar design was used for in vitro studies. The standard error of the mean was also calculated. In vitro results showed 80 to 100% mortality of first, second, and third instar stages of soybean looper within 5–24 hours using NC, NZO, and NS. Similarly, 80 to 100% mortality of first, second, and third instar stages of beet armyworm were observed within 5–24 hours using NC, NZO, and NS. In vivo application of NZO (5, 10, 15 mM), NS (5, 10, 15 mM), and NC (0.5%) showed less damage on soybean leaves using first instar stage of soybean looper. However, no effect of these particles were observed on second and third instar stages of soybean looper. In field conditions, five spray applications of NZO (5, 10, 15, 20 mM), NS (5, 10, 20 mM), NC (0.5% and 1.0%) at V1 (first trifoliate leaf) to V5 (five trifoliate leaf) stage of soybean development showed decline in leaf damage and blemishes in comparison to control treated plants. Behavioral studies were conducted in cages by enclosing the adults of Japanese and Cucumber beetle on NZO (15 and 20 mM) treated and control leaves. Adults never attacked on NZO treated leaves and preferentially consumed untreated control leaves. However, adults also consumed NZO treated leaves in the absence of control leaves in cages. These studies were conducted using a narrow range of nanoparticle. There is a possibility of more success in vivo conditions by using wide range of nanoparticles.

*Specified Source(s) of Funding: Maryland Soybean Board*

An asterisk (*) following a name indicates the presenting author.
We examined the hypothesis that the premature floral bud abscission that produces alternate bearing in pistachios is a function of carbohydrate status. This study focused on shoots with and without crop to better characterize the carbohydrate status at the individual branch level. At \( \alpha = 0.05 \) average percent abscission was significantly higher in “on” branches (91.5%), compared to “off” branches (50.1%). Additionally, carbohydrate analysis of individual branches showed a significant difference \( (P < 0.05) \) between the starch content of one-year-old wood and that of current-year wood of the same branch. Results suggest competition for stored carbohydrates in the new wood of fruit-bearing shoots may initiate a hormonal signal that precipitates bud abscission on current year’s shoot growth.

**Pecan Maternal Genotype: Implications for Nutrient Uptake in Alkaline Soils**

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Pecan (Carya illinoinensis) is native to Mexico and the southwestern United States (U.S.), spanning diverse humid to semi-arid environments. The southwestern U.S. is playing an increasingly significant role in pecan production, now comprising nearly 25% of improved U.S. pecan acreage. Suitable climate, low pest and disease pressure, deep soils, and the availability of irrigation water have led to rapid expansion of pecan acreage in the Southwest. Maximizing productivity and profitability requires identification of pecan rootstocks that can thrive in this region’s unique environment. High soil pH and lime content limit soil availability of micronutrients, resulting in severe nutrient deficiencies. In this study we investigated the interactive effects of pecan seedling maternal genotype and soil lime content on nutrient uptake in alkaline soils. We hypothesized that seedlings with western-region maternal ancestry are better adapted to extract nutrients from calcareous, alkaline soils than those with eastern- or southern-region ancestry. Eight maternal genotypes across the native range of pecan were used in this study: eastern-ancestry genotypes (‘Curtis’, ‘Elliott’, and ‘Moore’), western-ancestry genotypes (‘Riverside’, ‘VC1.68’, ‘Shoshoni’, and ‘Burkett’), and one southern-ancestry genotype (‘87MX1.5.7’). The seedlings were grown in 18.5-L pots under three soil lime treatments, representing the range of soil lime content in the Southwest. Agricultural lime was added to soil at 3 rates: 30% lime, 15% lime, and no added lime (“Control”). Each genotype × lime content combination was replicated six times. Trees received 30 g of 16N–3.5P–6.6K fertilizer six
Pistacia vera

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Oral Presentations

3:00 PM – 3:15 PM

Developing a Phenological Model to Manage Pistachio Production

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Pistachio (Pistacia vera L.) nut growth has 3 successive/simultaneous stages: 1) pericarp expansion growth that produces the final in-shell nut size; 2) thickening and hardening of the pistachio endocarp that is a process of lignification; and 3) and simultaneously with the late lignification, embryo growth. In pistachio, it is crucial for growers to know when these specific growth stages will happen to maximize efficiency of irrigation, pest management, and harvest time to optimize quality, yield and profit. Based on three years’ data, a pistachio nut growth model was developed to describe the three growth stages as a function of heat units for the cultivars Kerman, Lost Hills, Golden Hills, Kaleghouchi and Pete 1. The three nut growth stages were measured weekly starting with bloom and ending with harvest. Hourly temperatures were monitored in each location and the thermal unit accumulation was calculated with the base temperature of 7 °C. Four non-linear models—the Asymptotic Regression, Michaelis—Menten, 3-parameter Logistic, and Gompertz models—were coded and analyzed using R Statistics software with functions of SSasymoff, MMoff, SSlogis and SSgompertz, separately. The Gompertz model produced a better coefficient of determination and Akaike’s Information Criterion values. It best predicted pistachio nut growth at both low and high heat unit accumulation. Based on the selected Gompertz model, a service website, powered by the Spring Framework, was developed with harvest. Hourly temperatures were monitored in each location and the thermal unit accumulation was calculated with the base temperature of 7 °C. Four non-linear models—the Asymptotic Regression, Michaelis—Menten, 3-parameter Logistic, and Gompertz models—were coded and analyzed using R Statistics software with functions of SSasymoff, MMoff, SSlogis and SSgompertz, separately. The Gompertz model produced a better coefficient of determination and Akaike’s Information Criterion values. It best predicted pistachio nut growth at both low and high heat unit accumulation. Based on the selected Gompertz model, a service website, powered by the Spring Framework, was developed heat units by applying the prediction curve. Pistachio growers only need to input the orchard information of the bloom date, cultivar and location.

Specified Source(s) of Funding: California Pistachio Research Board

3:15 PM – 3:30 PM

Field Dust Damages Stigmatic Structure and Crop Production in Pistachio (Pistacia vera L.)

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Substantial dust generated by flail mowers in California’s Central Valley pistachio (Pistacia vera L.) orchards led to the hypothesis that field dust disrupts pollination and fruit set in pistachio. In spring, clusters with flowers at the green tip stage were bagged and hand-pollinated with pollen:dust mixtures at the different ratios on five successive days. The stigmatic structure, the rates of viable pollen, fruit set, nut drop, blank and nut split were all investigated as factors involved in the progress of pollen-stigma interactions. This study also evaluated the effect of herbicide residues in dust to both pollen viability and pistil morphological structure. The gibberellic acid (GA) concentration in the florets of the pollen and dust trials, and the bagged control was tested. In 2016 and 2017 both pollen viability and stigma quality were damaged by dust, resulting in a poor crop yield via decreased fruit set, increased parthenocarpy and a lower proportion of split nuts. The stigmatic surface were wilted and distorted following the dust contamination. The papillae cells disappeared in the toxic 1:1 trial. The GA content in flowers of both the pollen and dust treatments was higher than in the non-pollinated flowers, which suggested dust could stimulate the parthenocarpy of pistachio, and therefore nut blanking.

Specified Source(s) of Funding: California Pistachio Research Board
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### Citrus Crops (Poster)

**Citrus Root Production and Fruit Yield Improves with Raised Bed and Groundcovers** *(Poster Board #367)*

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Improved citrus management practices have become important as yields decline due to diseases, pests, and drought. Plastic mulch groundcovers are among some of the most promising practices being evaluated; improving water conservation by reducing evaporative losses from the soil, improving management of some pests and soil borne diseases, and limiting weed growth. These groundcovers can also promote deeper root systems and fine root production. In southern Texas, citrus are particularly vulnerable to drought due to the predominate method of flood irrigation, the subtropical climate, sporadic rainfall, and limited water resources. Flood irrigation causes significant water losses, nutrient losses, salt buildup, and erosion. Using alternative citrus management practices can potentially reduce the frequency and amount of water applied, but also has the potential to maintain water in the soil during times of drought and water scarcity. However, the initial cost of groundcover installation is a deterrent to many growers who would like to know if trees will come into production faster or yield more to defray the cost. To evaluate this, four management strategies were studied to evaluate tree growth rates and yield over 4 years and root growth and turnover for 2 years. Raised beds with groundcovers have led to increased root biomass, surface area, yields, and fruit weight. There were various impacts of groundcover and raised bed, but the combination of raised bed and groundcover seemed to have an additive impact on tree growth, yield, root production, and fruit quality. Furthermore, root biomass and area at deeper soil depths was increased compared to the conventional flat bed with no groundcover production system. Trees come into production faster and have greater yields, which should defray the costs associated with groundcover installation. Overall, using a raised bed with groundcover system shows positive impacts on production and holds much promise for citrus producers facing challenges due to water shortages, drought, or resource limitations.

**Specified Source(s) of Funding:** USDA/NIFA NNF Award No. 2014-38420-21798 Title: Sustainable Agriculture in Semiarid Areas: An International & Interdisciplinary Approach to Graduate Education, Texas Water Development Board Contract No#1513581823,

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### Assessment of Cold Hardiness of Citrus in North Florida after a Decade of Global Warming

*(Poster Board #368)*

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A warming climate during the last decade has renewed interest in the culture of citrus in north Florida and in the states bordering the northern Gulf of Mexico. This industry mainly consists of satsuma. Satsuma can withstand about –10 to –12 °C when properly cold acclimated. The fruit have few seeds, have a narrow harvest interval during November and must be clipped from the tree. There is ample justification for the diversification of citrus in north Florida to encompass the production of fresh market citrus from Mid-September thru December. Citrus packing houses and a juice plant have been established in north Florida to facilitate industry growth. Citrus Greening, which has decimated citrus production in the Florida peninsula, has not yet been detected in commercial groves in north Florida. Some of the cold hardy citrus that have been grown successfully in north Florida include ‘Early Pride’, ‘Minneola Honey Belle’, ‘Navel’, ‘Orlando Tangelo’, and ‘Sugar Belle’. The University of Florida (UF) Citrus Breeding Programs at the Citrus Research and Education Center in Lake Alfred have released the mandarin hybrids ‘Seedless Snack’ and ‘Bingo’ and several numbered selections (UF 900, UF 950 and UF C4-15-19) are under trial. In addition, the Citrus Breeding Program in Gainesville has just released the mandarin hybrids ‘UF Dawn’, ‘UF Glow’, and ‘UF Sunrise’. The above genotypes are currently under trial at the NFREC-Quincy. Young tree survival and tree growth have been improved by microjet freeze protection. One major goal is to identify fresh market commercial citrus that can compete in the Cutie/Halo Market from September thru December.

**Specified Source(s) of Funding:** Florida Department of Food and Agriculture Specialty Crop Grant

### Intra-Plant Movement of Candidatus Liberibacter asiaticus in Citrus

*(Poster Board #369)*

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Huanglongbing (HLB) is a disease complex that in Florida putatively involves the gram-negative bacteria Candidatus Liberibacter asiaticus (CLas), the psyllid vector Diaphorina citri Kuwayama that introduces CLas into sieve tube elements of phloem, and secondary stresses that take advantage of the weakened tree. In commercial groves, the combined factors promote the most serious symptoms of decline. In greenhouses where psyllid vectors are excluded and secondary stresses minimized, a single inoculation of trees promotes only mild symptoms.
The better growing conditions in greenhouse studies have also demonstrated that CLas is capable of moving into new growth, but the pathway is currently not known. Four hypotheses on intra-plant movement of CLas are presented and discussed, including 1) sieve tubes naturally develop into a network that extend the full length of the tree and develop across growth flushes, 2) the presence of CLas species promotes development of a network of sieve tubes that extend the full length of the tree and develop across growth flushes, 3) the host’s cell walls become debilitated allowing CLas to traverse the apoplast, and 4) sieve tube injury by mechanical or pathogenic processes allows CLas to move from infected to uninfected sieve tubes. Elucidating the mode of intra-plant movement of CLas species will facilitate development of strategies that impede movement and coupled with strong psyllid-vector suppression programs in commercial groves should help citrus trees “grow” out of HLB by restricting CLas to old phloem.

Specified Source(s) of Funding: Integrated Plant Health Services LLC

**Field Evaluations of Trichoderma asperellum As Biocontrol Agent Against Phytophthora Foot and Root Rot in Citrus (Poster Board #371)**

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Citrus production in south Texas is largely affected by Phytophthora foot and root rot disease. The causal agent, Phytophthora nicotianae, is an oomycete that causes root rot and trunk gummosis, leading to poor yield, tree decline, and eventually tree death. Trichoderma spp. is a soil fungi capable of suppressing several plant pathogenic fungi including Phytophthora spp. Our previous studies revealed that native Trichoderma isolates possess anti-fungal activity against P. nicotianae in vitro. One isolate showed strong mycoparasitism and sequence analysis confirmed it as Trichoderma asperellum. Greenhouse evaluations showed that T. asperellum protected citrus seedlings from P. nicotianae infection and promoted seedling growth. The aim of this study was to continue the evaluations of Trichoderma by performing field evaluations on the effectiveness of T. asperellum in preventing Phytophthora infections and its impact on tree growth. Applications of T. asperellum were performed in three different locations in South Texas, with each site planted with Rio Red grapefruit trees at different developmental stages (new planting, 2 years old and mature trees), Phytophthora populations, and infection levels. Initial measurements were recorded to assess differences between treated and untreated trees. Evaluation of tree growth parameters such as tree height, leaf area and trunk diameter have been performed every three months in each location for a year. Phytophthora quantification revealed that soil propagules were reduced after six months post application. Significant differences were not observed in growth parameters of trees between treated with T. asperellum and untreated control within first year of the study. The ongoing field studies will further determine T. asperellum as potential biocontrol agent against Phytophthora foot and root rot.

Specified Source(s) of Funding: Texas Citrus Producers Board

**Interaction of Huanglongbing and Foliar Applications of Copper on Growth, Nutrient Acquisition, and Water Relations of ‘Valencia’**

(Poster Board #372)

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The following study was conducted to determine the impact of frequent foliar Cu applications, which are used to suppress citrus canker caused by Xanthomonas citri subsp. citri in commercial groves, on Huanglongbing (HLB)-affected Citrus sinensis cv. Valencia. The experiment was conducted in a psyllid-free greenhouse with HLB positive and non-HLB control trees grown in Immokalee fine sand soil and well-maintained to promote health. Cu was applied to the foliage at 0×, 0.5×, 1×, and 2× of the commercially-recommended rate, which were 0, 46, 92, and 184 mM, respectively, with applications made 3x in both 2016 and 2017. The impact of HLB and Cu treatments on leaf and root Cu concentrations, vegetative growth, Candidatus Liberibacter asiaticus titer, acquisition of other essential nutrients, and water relations were determined. HLB acidified the soil more than non-HLB controls, which promotes Cu availability and promoted higher Cu contents in leaves and roots. HLB and Cu application treatments suppressed leaf area and total root length observable in rhizotron tubes such that by the end of the experiment leaf, stem, root and whole plant dry weights were reduced. HLB reduced foliar concentrations of Ca, Mg, Mn, Zn and possibly Fe, but HLB did not affect root concentrations of these same essential nutrients. Cu application treatments did not affect leaf or root concentrations of other essential nutrients except foliar content of Fe which may have been suppressed. HLB suppressed stem water potential slightly compared to the non-HLB controls. Stomatal conductance and transpiration flux were reduced at the higher rates of Cu applied. Traditional recommendations for Cu applications to control HLB may have to be reconsidered in commercial citrus groves due to the impact on growth and development.

**Effect of Propagation Methods on Citrus Rootstock Water Uptake**

(Poster Board #373)

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An asterisk (*) following a name indicates the presenting author.
Huanglongbing or greening disease increased the need for new plantings and resetting in the field. To meet the high tree demand, citrus nurseries need high-quality, fast-growing rootstocks. Vegetative propagation is an alternative to the traditional seedling production due to the increased turnaround in the nursery. However, it may induce changes in the root system architecture and the development of adventitious roots instead of the taproot, altering root morphology and potentially the water uptake performance. The objective of this study was to compare the plant water uptake of citrus rootstocks propagated using different methods. We tested four citrus rootstocks (‘Swingle’ [Citrus paradisi × Poncirus trifoliata], ‘US-942’ [‘Sunki’ (Citrus reticulata) × ‘Flying Dragon’ (Poncirus trifoliata)], ‘US-897’ [‘Cleopatra’ (Citrus reticulata) × ‘Flying Dragon’ (Poncirus trifoliata)], and ‘US-802’ [‘Siamese’ (Citrus grandis) × ‘Gotha Road’ (Poncirus trifoliata)]) and three propagation methods (seed propagation, stem cuttings and tissue culture). The study was arranged in a split-plot design with rootstocks as the main plot factor, and propagation methods as the subplot factor. Main plots were arranged in a completely randomized design with four replications with four trees each. Trees were planted in Nov. 2017, spaced 1.2 × 7.0 m apart, and received the same cultural practices. Microsprinklers were set under a daily irrigation schedule, and trees were fertilized using control-released fertilizer. Plant water uptake was measured using 48 sap flow sensors (SF3; Edaphic Scientific, Port Macquarie, Australia) to estimate transpiration rate. Data were obtained every 15 minutes using a set of data loggers (CR1000X; Campbell Scientific, Logan, UT) and multiplexers (AM16/32B; Campbell Scientific) installed in the field in waterproof boxes. The system was completely powered by rechargeable batteries and solar panels. The 3-needle sap flow sensor was inserted into the trunk of 1-cm diameter young trees selected randomly in the field. Daily water uptake followed the evapotranspiration pattern as reported by the Florida Automated Weather Network. ‘US-802’ propagated by stem cuttings and tissue culture presented lower transpiration rates, while seed propagation the higher values. ‘Swingle’ and ‘US-897’ presented the lowest transpiration rates when propagated by seeds. Propagation methods affected the water uptake in field conditions for the initial tree development stages (4–6 months after planting) in some rootstocks tested. New propagation methods have the potential to accelerate rootstock production and meet the existing tree demand without interfering in adequate water uptake. However, long-term effects are unknown and still under evaluation.

Specified Source(s) of Funding: Funding for this research was provided by the UF/IFAS 2017-2018 Citrus Initiative.
Poster Presentations

Evaluation of Pruning and Controlled Release Fertilizer to Rehabilitate Huanglongbing-affected Sweet Orange Trees (Poster Board #375)

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Previous research has shown that Huanglongbing (HLB)-affected trees have a reduced root system and a higher rate of root turnover. The diminished root system cannot support the existing above ground canopy and fruit production; as a result, the tree enters into a continuous carbohydrate stress cycle and the tree declines in overall health. Therefore, the objective of this study was to evaluate different levels of pruning as method to correct for root to shoot ratio and improve growth and productivity of HLB-affected trees. In January of 2015, a three-year trial was initiated, 15-year-old grove of ‘Hamlin’ on ‘Swingle’ rootstock were divided for four pruning treatments. The four pruning treatments were: 1) 0%, no canopy removal; 2) 25% reduction; 3) 50% reduction; and 4) 80% reduction. The two sources of fertilizer used were: 1) conventional fertilizer (dry granular; CNV) applied at 200 lb/acre nitrogen in 5 split applications and 2) controlled release fertilizer (CRF) applied at 150 lb/acre nitrogen, split in three applications. Within each pruning treatment, half of the trees received conventional fertilizer (CNV) and the other half received CRF. All the trees that were pruned produced new flush that looked healthy with no HLB symptoms (initially). The 80% pruned trees grew vigorously over the course but are still significantly smaller than the canopy of control trees (0% pruning) for both CRF and CNV. The 25% and 50% pruned tree canopies grew back and were similar in canopy size as 0% control pruning treatment by the end of year 2. In the first year, the yield for 25%, 50%, and 80% were significantly lower. In the second and third year, the yields of all pruned trees were significantly improved and there was no significant difference between 0, 25, and 50% pruning. A significant correlation was observed between canopy volume and yield. The brix value of juice from the fruit was observed to decrease with a decrease in canopy volume. A clear inverse relationship between canopy volume and preharvest fruit drop was observed. Overall, our results indicate that pruning did not improve the productivity HLB-affected trees over the course of three years. Therefore, pruning may be viable option to rejuvenate the HLB-affected trees. No significant differences were observed between the two forms of fertilizer for any of the measured parameters, therefore with use of CRF amount nitrogen and frequency of application can be reduced.

Stop the Drop: A Comparative RNA-Seq Analysis of Sugar Belle and Hamlin Fruit Abscission Zones (Poster Board #376)

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Fruit drop is one of the many HLB symptoms and is the main cause of yield loss in citrus production. Results from the UF-CREC citrus breeding program show that Sugar Belle has tolerance to HLB, good yield, vigorous growth, and can retain its fruit for 30 days past optimum maturity. Compared to Hamlin, which is very susceptible to HLB and subjected to a high fruit drop rate. Our hypothesis is that Sugar Belle abscission zone (AZ) has a low expression of cell wall degradation, ethylene, auxins and abscisic acid pathway biosynthesis, thereby decreasing fruit abscission when compared to Hamlin AZ. Twenty Sugar Belle and Hamlin fruits were collected from 16 trees (8 per variety) in November 2016. Fruits were pulled from stems and the force to detach was measured. Fruit that detached with a force below 5 kgf were considered loose fruit, and equal or above 5 kgf were considered tight fruit. Fruit abscission zone RNA from homogenous samples of loose and tight Sugar Belle and Hamlin fruit were extracted and sequenced. Over 16,000 genes were differently expressed. A threshold of four-fold change was used to filter the full sequence data resulting in 699 different expressed genes. Genes related to pectin, carbohydrate transport, response to hormones, and abscisic acid signaling were downregulated in Hamlin. Lignin-related genes were overexpressed in Hamlin. Upregulation of ethylene and cell wall degradation related genes were found in Sugar Belle AZ, indicating initiation of the abscission pathway, however Sugar Belle fruit remain attached to the stems. Our RNAseq results suggests that low fruit drop in Sugar Belle is not associated with altered expression of abscission related genes. Further, anatomical and physio-chemical studies could explain why Sugar Belle fruit endure the abscission process.

Specified Source(s) of Funding: UF/IFAS Early career seed grant and Citrus initiative

Quantifying Citrus Tree Health & Disease Progression Using True Color UAS Images (Poster Board #377)

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Citrus diseases, like Huanglongbing (HLB) and Phytophthora, are challenging to citrus growers in the Lower Rio Grande Valley (LRGV) due to their impacts on yield and production. These diseases are associated with symptoms and physiological changes which can be evaluated through field measurements to
help quantify their impacts on tree health. Nonetheless, physiological measurements, such as tracking crop physiological stages, health status, disease progression, and yield potential, can be difficult to determine due to environmental factors, inaccessibility, etc. To address this concern, unmanned aerial systems (UAS) have recently been introduced as an innovative way to monitor crop growth and production factors. Current UAS research has focused on a graphical display using near infrared (NIR) cameras to determine tree health. While this has had promising success in tree evaluation and health assessment, equipment and cameras are cost prohibitive to many growers. One less expensive alternative is red/green/blue (RGB) or true color imaging, for remote sensing and crop evaluation. True color images can provide farmers with data that is informational and practical for monitoring citrus trees. To assess its feasibility in tree evaluation, we will fly a DJI Phantom 4 Pro Quadco aircraft with a RGB camera every 4 months in 2017 and 2018. The objective is to determine if true color images can provide accurate data on citrus health using less expensive and labor intensive methods. Preliminary assessments of tree health in a HLB affected field of ‘Rio Red’ grapefruit trees on three different rootstocks indicate that HLB distribution varies by location and rootstock. Of the rootstocks surveyed, trees on C146 rootstocks had a lower incidence of Phytophthora infection and HLB + Phytophthora infection. Additionally, the percentage of healthy trees was highest in trees on C146 rootstocks followed by trees on C22 rootstocks and C57 rootstocks. UAS images have been collected and are currently being processed for correlation with these field findings.

Commercial Horticulture (Poster)

LSU Ag Center 2017 Red Cabbage Variety Trial (Poster Board #085)
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Red cabbage is a commonly grown cool season vegetable. In Louisiana, cabbage is primarily sold at fresh markets, where head size is of concern to buyers. Typically green cabbage produces a larger and heavier head than red cabbage produced in Louisiana. Therefore a variety trial was conducted to determine if a particular variety of red cabbage yields heavier weights than others grown when grown in the fall season. Nine varieties were planted at a farm in southeast Louisiana. The heaviest yielding red cabbage variety was ‘Rio Grande Red’.

Crop Load Reduction in Peach (Prunus persica L.): The Effects of Timing and Intensity (Poster Board #086)
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Floriculture 1: Cut Flowers, Water Quality (Poster)

Development and Evaluation of Long-Stemmed Pepper (Capsicum) Lines for Use As Ornamental Cut Stems (Poster Board #089)
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Inclusion of stems of showy fruits or vegetables bearing colorful small fruits can make a welcome and attractive addition to summer and fall floral bouquets. Although pepper (Capsicum annuum) plants have been developed as high-value ornamental bedding plants, with prominent small fruits, stem length of these plants is too short for use in floral arrangements. This limitation is being overcome by two means: (A) Selection of C. annuum lines at USDA, ARS, Beltsville, with tall stature, black/dark violet-colored foliage and small fruits; and (B) Tall selections of Capsicum baccatum, sourced from the USDA National Plant Germplasm System. The C. annuum material is derived from initial crosses between the black foliage USDA pepper germplasm release 90C44 and diverse heirloom cultivars including ‘Christmas Cheer’, ‘Royal Black’ and others. In con-
trast with black foliage ARS releases such as ‘Black Pearl’ and Midnight Creeper®, early generation selections for cut stem lines focused on tall indeterminate growth habit. Selection was practiced for plants that produce greater than three basal shoots and have vigorous indeterminate upright growth habit. Selections exhibited good retention of black foliage on cut stems in 7-day trials. Fruits are oriented upright, of various shapes from round to blocky to pointed, glossy black when immature, and mature to orange or red when mature. The C. baccatum lines were first grown at Cornell University in 2011, and evaluated for stem strength, lodging resistance and ease of leaf removal in the next four years. Primary interest of the C. baccatum selections resides in colorful red, yellow or orange upright oriented fruit of diverse size and shape. Ease of manual leaf removal varied from year to year, but placing the cut stems in a dark, humid box and subjecting them to 30 °C for 3 days accomplished complete defoliation. Selections from five lines, namely PI 159252, PI 441525, PI 441542, PI 441552 and PI 441575 had the most desirable traits and are being offered for distribution to seed companies for commercialization and distribution as named varieties. Both the C. annuum and C. baccatum lines are being evaluated by cut flower growers in field plantings in Maryland and Virginia in the 2018 planting season.

**Plant Growth Regulator Pulses Improve Dahlia Flower Quality and Extend Vase Life**
*(Poster Board #090)*

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Cut dahlia (*Dahlia Cav.*) flowers are perennially popular with consumers and command a relatively high per-stem price. Due to their short postharvest longevity, growers are always seeking ways to extend dahlia vase life for consumers. Pulses of flowers with plant growth regulator achieves this goal in species such as alstroemeria, carnation, gladiolus, and iris. Gibberellic acid (GA) delays flower wilting and senescence in some species and is an antagonist to abscisic acid, which promotes those processes. Cytokinins can extend vase life of some cut flowers and has been shown to do so in a few dahlia cultivars. We investigated the influence of pulse treatments of benzyladenine (BA), GA$_{4+7}$, and the commercial solutions Fresco® and Chrysal BVB on vase performance of dry-shipped, cut dahlia species ‘Amora’, ‘Natalie G’, and ‘Prospero’. Fresco®, which provides equal amounts of both BA and GA$_{4+7}$, at the concentrations indicated in one solution, was used at 5, 10, 20, 30, and 50 mg·L$^{-1}$. The five other treatments were 20 mg·L$^{-1}$ BA, 2mg·L$^{-1}$ GA$_{4+7}$, 2 mg·L$^{-1}$ Chrysal BVB, combined 20 mg·L$^{-1}$ Fresco® and 2 mg·L$^{-1}$ Chrysal BVB, and tap water control. Fresh-cut stems were pulsed for 24 h in a 5 °C cooler before placing them into vases for consumer vase life determination. Most of the variables assessed were not influenced by the pulse treatments: solution uptake during pulse treatment, water uptake while in vase, change in vase water pH or EC, stem fresh weight change or dry weight at termination. Fresco® increased vase life (by 35% across cultivars) and flower quality after 4 days in vase compared to tap water in all three cultivars, and 5 mg·L$^{-1}$ (‘Natalie G’, ‘Prospero’) or 10 mg·L$^{-1}$ (‘Amora’) were as good as or better than higher concentrations. Pulsing flowers with 2 mg·L$^{-1}$ Chrysal BVB did not improve vase life or flower quality after 4 days in vase compared to tap water, and adding it with 20 mg·L$^{-1}$ Fresco® could negate the benefit of Fresco®. Depending on the cultivar, the increased vase life and/or higher flower quality after 4 days in vase achieved by using Fresco® was seen with BA alone, GA$_{4+7}$ alone, or neither plant growth regulator on its own.

**Specified Source(s) of Funding:** Bloomia USA

**The Influence of Planting Density on the Production of Specialty Cut Sunflowers**
*(Poster Board #091)*

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Plant density is critical in the growth and development of specialty cut sunflower (*Helianthus annuus* L.) cultivars. An experiment was conducted to evaluate four plant spacings; 8 × 15, 15 × 15, 23 × 23, and 30 × 30 cm using three non-branching sunflower cultivars ‘Pro Cut Gold’, ‘Sunrich Lemon’, and ‘Superior Gold’. Stem length, stem diameter, flower diameter disk diameter, days-to-harvest and number of marketable stems were determined at harvest. The 30 × 30 spacing resulted in the largest stem diameter, flower diameter, disk diameter, fewest days-to-harvest and higher percentage of marketable stems. Stem length was not significantly different for the other spacings, but tended to increase with plant density. The percentage of stems that were marketable declined significantly to 54% for the 8 × 15 cm spacing compared to 96% for the 30 × 30 cm spacing. While the percentage of marketable stems declined, the number of stems per area increased from 10, 15, 28, and 44 stems m$^{-2}$ for the 30 × 30, 23 × 23, 15 × 15, and 8 × 15 cm spacing, respectively. ‘Superior Gold’ a vigorous cultivar produced marketable stems at all four spacings. ‘Pro Cut Gold’ produced marketable stems at the 23 × 23 and 30 × 30 cm spacing and ‘Sunrich Lemon’ failed to produce marketable stems. This initial experiment indicates that increased plant density reduced sunflower size while producing more marketable sunflower stems, however cultivar selection may be critical.

**Reducing Post-infection *Botrytis* Damage in Cut Roses with Essential Oil Vapor** *(Poster Board #092)*

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An asterisk (*) following a name indicates the presenting author.

**Poster Presentations**

**Botrytis cinerea** is a large problem during cut rose production and in the postharvest environment. Cultural practices that take place during rose production in greenhouses can lead to spore dispersal that increases the infection risk. The objective of this research was to evaluate the relationship between **Botrytis** spore density and cultural practices in commercial greenhouses of cut rose production, additionally changes on **Botrytis** spore density were evaluated across weeks. To achieve this, two spore samplers were placed in commercial greenhouses to collect daily air samples, and a daily report of all the cultural practices performed at the greenhouse was obtained. After 300 days of data collection, analysis of variance was used to determine the correlation between each cultural practice on the **Botrytis** spore density. The results showed that mechanical removal of plant debris from the rose canopy, plant growth regulator application (which involves removal of plant debris from the surface of the growing media, movement of the top layer of growing media, and drench application of the growth regulator), sweeping of floors, realigning the canopy (returning errant shoots to the plant canopy) and harvesting were more closely correlated to the spore density data. Variations on the spore density were determined between weeks. Additionally, Wednesday, Thursday and Friday (days with more cultural practices) presented a consistently higher spore density while Sunday (day with the less or none cultural practices) showed the significantly lowest spore density.

**Specified Source(s) of Funding:** American Floral Endowment

**Agrobacterium Infiltration for Transient Expression of F3’5’H, Rosea1, and Delila in Detached Anthurium Spathes** *(Poster Board #094)*

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Anthurium is the highest selling cut flower in the Hawai‘i floriculture industry. The major colors in the market include red, orange, pink, white, and green. Continuous development of novel colored anthuriums will help to keep the Hawai‘i industry globally competitive. One approach for the development of novel color is genetic modification of the anthurium color pathway with exogenous genes. However, anthurium is slow growing and the visualization of exogenous gene expression on

**Evaluating Botrytis spore Density in Commercial Cut Rose Production** *(Poster Board #093)*

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Anthruthium is the highest selling cut flower in the Hawai‘i floriculture industry. The major colors in the market include red, orange, pink, white, and green. Continuous development of novel colored anthuriums will help to keep the Hawai‘i industry globally competitive. One approach for the development of novel color is genetic modification of the anthurium color pathway with exogenous genes. However, anthurium is slow growing and the visualization of exogenous gene expression on

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spathe color takes several years from transfection to flowering. Alternatively, transient expression via Agrobacterium infiltration is a rapid method to visualize the functionality of exogenous color genes introduced to the anthurium anthocyanin pathway. Detached spathes of anthurium ‘New Era’ were agroinfiltrated with structural gene F3’5’H, or the transcription factors Rosea1, or Delila, individually or as a combination of all three genes. Control plants were treated with only the infiltration buffer and no Agrobacterium. Color change was observed at the sites of infiltration in spathes treated with Delila and the combination of F3’5’H, Rosea1, and Delila approximately 134 hours post treatment. Control spathes and spathes infiltrated only with F3’5’H or Rosea1 did not show any color change at the sites of infiltration. Additional experiments will examine the transient expression of paired combinations of F3’5’H, Rosea1, and Delila.

**Growth of Vinca in Response to Irrigation with Saline Water** *(Poster Board #095)*

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Salinity stress is a major limiting crop production. Excessive salts in the root zone create osmotic stress limiting the ability of plants to take up water leading to reductions in growth. It is well established that plant growth will be reduced when watering with water high in salts due to salt water intrusion, reclaimed waste water use or over fertilization. We questioned if the use of plant hormones applied prior to a salt event would improve plant performance when irrigated with salt water. We compared growth and flowering of vinca (Catharanthus roseus) watered with tap water or saline water and treated one time with no hormone, 0.75 mM jasmonic acid (JA) or 0.75 mM abscisic acid (ABA). The tap water had an electrical conductivity (EC) level of 0.5 dS m⁻¹ while the salt water had an EC of 12 dS m⁻¹. Vinca shoot dry weight was greater for containers watered with tap water than salt water. There was no difference in shoot dry weight due to hormone application. There also was no difference in flower numbers due to hormone application but there were more flowers on plants watered with tap water than salt water. We also observed greater final tissue electrolyte leakage for all hormone treatments for plants watered with salt water. Final tissue proline levels for plants without hormone were not different between tap and salt water but tissue proline levels for plants treated with JA and ABA were greater in plants watered with salt water than tap water. It appears that the one time application of JA and ABA were insufficient to mediate damages due to watering with salt water.

**Grey Water As a Viable Alternative for the Growth of 10 Common Geophytes** *(Poster Board #096)*

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Ornamental plants are an integral part of landscapes, and maintaining their visual quality is imperative to the their success. The premium placed on fresh water as a valuable resource makes it increasingly more difficult to plant ornamentals in urban areas or other areas where water scarcity is common. As high quality water becomes scarcer and more valued it is important to know which ornamental plants can tolerate stress while maintaining visual quality. In areas facing increased water scarcity, it is possible that grey water can be used for ornamental production and maintenance. The purpose of the research was to determine the viability of utilizing grey water for greenhouse production of 10 common autumn bulbs (3 daffodil, 2 tulip, 2 crocus, 1 allium, 1 iris, and 1 hyacinth cultivars). Growth, flowering time, flower duration, and nutrient analysis were utilized to determine the impact of grey water. Grey water irrigation did not significantly alter leaf length, leaf number, flower number, flower duration and leaf water status compared to the control. However shoot biomass was significantly reduced in the grey water treatment, with the greatest reduction in hyacinth (reduction of 30%). Leaf chlorophyll content was comparable between the grey water treatment and the control after 119 (28 days of treatment) of treatment, but by 140 days of treatment (49 days in the greenhouse) chlorophyll content was reduced in the grey water treatment compared to the control. Despite this decrease we did not observe a decrease in carbon assimilation, stomatal conductance and transpiration rate. Our results indicate that grey water would be a viable irrigation source for 10 fall bulb species.

**Growth Chambers and Controlled Environments 1 (Poster)**

**Capabilities of the Controlled-environment Lighting Laboratory Propel Vertical Farming Research** *(Poster Board #139)*

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An asterisk (*) following a name indicates the presenting author.

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Supplemental lighting (SL) is necessary for optimal plant growth and yield in greenhouse tomato production, particularly during winter months in temperate climates. Over-head (OH) high-pressure sodium (HPS) lamps presently are the most common type of SL because of their high-intensity capabilities. The leaves at high canopy receive more light than the leaves at low canopy due to light gradient caused by OH-HPS and shading of high canopy on low canopy. Intracanopy (IC)-light-emitting diode (LED) towers provide a uniform lighting environment vertically along the plant canopy without emitting radiant heat and have a more efficient light spectrum to enhance photosynthesis. Ion uptake, partitioning and assimilation are highly dependent on photosynthesis and transpiration. However, there is no report about how microenvironment created by light resource affects photosynthesis and transpiration, thus ion accumulation, partitioning and fruit quality. The objective of this study was to determine how different SL sources [OH-HPS vs. IC-LED] affect ion accumulation, partitioning and fruit quality of high-
wire greenhouse tomato. ‘Merlice’ scions grafted onto ‘Maxifort’ rootstocks were supplemented with IC-LED (100% red light) and OH-HPS (4% blue light: 48% green light: 48% red light). Un-supplemental lighting control (ULC) was also included. Plants were fertigated with a commercial complete fertilizer mix (4.5N–14P–34K; CropKing, Lodi, OH) to maintain acceptable electrical conductivity and pH in the root zone, and irrigation duration and frequency were adjusted to provide a daily leaching fraction of 30%. Photosynthetic and transpiration rates were measured with a portable photosynthesis system. The concentration of nitrate, nitrite, sulfate, phosphate, chloride, sodium, potassium, magnesium and calcium in leaf, stem, root and fruit were determined by ion chromatography. Compared to OH-HPS, IC-LED-grown tomato with uniform lighting accumulates more nitrate, nitrite, sodium, potassium, magnesium and calcium in whole plant due to higher photosynthesis and dry mass accumulation. Vertical light gradient of OH-HPS induced stem elongation and higher biomass allocation to stem, which significantly increased the partitioning of sodium, potassium and calcium to stem compared to IC-LED. Moreover, OH-HPS induced more partitioning of nitrate from root to leaf compared to ULC resulting from higher transpiration at higher canopy. Compared to OH-HPS, IC-LED increased concentration of manganese by 38% and lowers the concentration of sulfate by 68% in tomato fruits, which may improve the fruit quality and aroma. Overall, IC-LED optimized photosynthesis, thus ion uptake, partitioning and assimilation, possibly improving fruit quality and aroma.

Specified Source(s) of Funding: NE-1335 Resource Management in Commercial Greenhouse Production

Accurate PAR Measurements: Spectral and Directional Errors of Seven Quantum Sensors

(Poster Board #142)

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Photosynthesis is driven by photosynthetically active radiation (PAR), which is almost universally defined as photosynthetic photon flux density (PPFD, the integral of photon flux density in units of mmol·m⁻²·s⁻¹ from 400–700 nm). Accurate measurement of PPFD is essential because of the close relationship between photosynthesis and plant growth. Quantum sensors (so called because a photon is a single quantum of radiation) are the most common device used for PPFD measurement because they are simple and relatively low cost. Quantum sensor accuracy is determined by both spectral response and directional response. Spectral response is the sensitivity to photons at each wavelength, or a measure of how well a sensor matches the defined plant response (equal weighting to photons between 400 and 700 nm, no weight outside this range). Directional response is the sensitivity to radiation incident at different angles, or a measure of how well a sensor matches Lambert’s cosine law (radiation intensity is proportional to the cosine of 90-minus-the-angle between the incident radiation beam and a horizontal surface). Here we compare spectral and directional errors for seven quantum sensors/meters: Apogee original (model SQ-100) and full spectrum (model SQ-500); Kipp & Zonen (model PQS 1); LI-COR original (model LI-190) and improved (model LI-190R); Spectrum LightScout; and Hydrofarm Quantum PAR Meter. Spectral and directional errors were less than 5% for the Apogee full spectrum, Kipp & Zonen PQS 1, and both LI-COR models. The Apogee original and Spectrum LightScout use photodetectors that are not sensitive to photons with wavelengths greater than about 660 nm, which can cause significant spectral errors under some radiation sources. These errors are partially accounted for by calibrating to specific radiation sources (as is the case for the Apogee SQ-100), but these sensors should be used with caution when measuring deep-red LEDs or other electric lights with significant radiation at wavelengths greater than 660 nm. The Hydrofarm Quantum PAR meter was found to have directional errors of up to 20% in the diffuse light that is characteristic of growth chambers, with larger errors in low-angle directional light. This meter should be used with caution in commercial and research applications.

Growth and Physiological Responses of Lettuce Grown under Pre-dawn or End-of-day Sole-source Light-quality Treatments

(Poster Board #143)

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Skarleth Chinchilla
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In order to understand the physiological factors that drive plant responses to spectral changes over time, the objective of this study was to evaluate growth and gas-exchange of ‘Cherokee’ and ‘Waldmann’s Green’ lettuce (Lactuca sativa) treated with light-quality changes within a 24-hour period. Three pre-dawn (PD: 0600 to 0700 HR) and three end-of-day (EOD: 2100 to 2200 HR) treatments were evaluated in the study, each providing 50 ± 2 μmol·m⁻²·s⁻¹ of either blue, red, or white light from light-emitting diodes (LEDs). To account for the main daily light integral (DLI), white LEDs provided 210 ± 2 μmol·m⁻²·s⁻¹ from 0700 to 2200 HR or from 0600 to 2100 HR for the PD or EOD treatments, respectively. A control treatment was included that provided 200 ± 2 μmol·m⁻²·s⁻¹ of white light from 0600 to 2200 HR. All treatments provided a DLI of 11.5 mol·m⁻²·d⁻¹ a 17-h photoperiod. Regardless of cultivar, no treatment difference was measured for hypocotyl length or leaf number. However, plants grown under EOD-blue or PD-white had up to 26% larger leaves than those grown under PD-red and 20% larger leaves than control. In addition, plants grown under EOD-blue produced up to 18% more shoot fresh mass (FM) compared to those grown under control, EOD-red, or PD-red. Contrasts for gas-exchange data collected during the main photoperiod showed that light quality was not significant within PD or EOD for any of the parameters evaluated. However, regardless of light quality, stomatal conductance (gs) and transpiration (E) were up to 34%
and 42% higher, respectively, for EOD-grown plants compared to control. Our results suggest that 1 h of low intensity EOD-blue light has potential to promote lettuce growth by increasing leaf area and FM when the main DLI from sole-source lighting is provided by white light. Furthermore, they indicate that regardless of light-quality, short-term exposure to EOD-light stimulates higher gs and E during the day, which may increase the photosynthetic efficiency of plants during the light period.

**The Effect of UV-A for Coloring of Red Leaf Lettuce under Plant Factory Conditions**
*(Poster Board #144)*

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We investigated the effect of ultraviolet-A (UV-A) light for coloring red-leaf lettuce (*Lactuca sativa* L. s. var. *crispa*) under controlled culture conditions (plant factory). It is well known that anthocyanin, which is the main pigment in red-leaf lettuce, induces by ultraviolet light exposure. Red-leaf lettuce varieties do not turn red in plant factory condition, because recent artificial lights (such as white, light-emitting diode or fluorescent lights) do not contain enough ultraviolet light. We tested additional UV-A equipped with white cold cathode fluorescent lamp. We grew plants on a hydroponic culture in plant factory conditions. The results showed that applying UV-A accelerated the coloring of red-leaf lettuce. However, the growth was inhibited under long-term exposure to UV-A conditions. This technique might be efficient for growing red-leaf lettuce cultivation in plant factories although a suitable treatment would be needed.

**Light Spectrum Affects the Response of Greenhouse Cucumber to Long Photoperiod of Intra-canopy Lighting** *(Poster Board #145)*

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Supplemental lighting is essential for year-round greenhouse crop production in regions with low natural light conditions. The supplemental lighting for increasing daily light integral can be added via lengthening photoperiods or increasing light intensity or both. Light addition via long photoperiods is more economical because less light fixtures are required, assuming the long photoperiods don’t affect the response of plants to lighting. However, photoperiods longer than 17 or 18 h cause photo-injury such as leaf chlorosis in greenhouse tomatoes, cucumbers and sweet peppers, limiting the yield increase at long photoperiods of lighting. Light spectrum could affect the response of plants to long photoperiods of lighting. Therefore, this study was conducted to investigate the influence of light spectrum on the response of greenhouse cucumber to long photoperiods of intra-canopy light-emitting diode (LED) lighting. The study was conducted in a large greenhouse (200 m²) during the winter 2017–18. The greenhouse was divided into four sections (50 m²/section) so that two top LED light spectral compositions (100% red or mixed — red:blue:white = 76:16:8, at 18-h photoperiod and 140 µmol·m⁻²·s⁻¹) could be applied with 2 replications. Four intra-canopy light photoperiods (18, 20, 22, and 24 h at 40 µmol·m⁻²·s⁻¹ of LED lighting, 87% red and 13% blue) were applied to the 4 plots inside each section. The long photoperiods (even if at 24 h) did not cause any significant difference in leaf chlorosis but did result in mis-shaping (cupping) in the middle leaves. The plants grown at 100% red top light had less mis-shaped leaves than at the mixed top light. Therefore, leaf chlorosis might not be photoperiodic in nature or might be more related to the physiological age of the leaf at the time of light exposure, and light spectrum did impact the response to long photoperiods. The perspectives of using different light spectra and intra-canopy lighting to extend photoperiods and reduce initial light fixture costs in supplemental lighting will be discussed.

**Effects of Narrow Bandwidth Light-emitting Diodes on Petunia and Spathiphyllum** *(Poster Board #146)*

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Plant growth and physiology are regulated by light quality, duration and intensity. Light-emitting diodes (LEDs) have the potential to be used as supplemental and sole light sources in greenhouses and growth chambers respectively. However, quality of light required by many ornamental plants including petunia and spathiphyllum are still unknown. In this study, we used different narrow bandwidth LEDs to determine specific wavelength of light required by petunia and spathiphyllum. The vegetative cuttings of *Petunia xhybrida* ‘Mitchell Diploid’ and two varieties of spathiphyllum (Ty’s pride and Mojo) plantlets were grown under five LEDs; red (660 nm), yellow (600 nm), green (525 nm), blue (450 nm) and white (control) which delivered a photosynthetic photon flux (PPF) of 100 mmol·m⁻²·s⁻¹ for 16 hours per day. Maximum plant height was observed under blue...
Effect of Light Spectrum on Pigment Accumulation and Expression of Pigment Biosynthesis Genes in Red Leaf Lettuce

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Previous studies have demonstrated the impact of light quantity and quality on anthocyanin accumulation in red leaf lettuce. In this experiment we studied the effect of a 48-h spectral shift on the temporal dynamics of pigment concentrations and expression of genes in the anthocyanin pathway. Seedlings of lettuce (*Lactuca sativa*) ‘Rouxai’ were grown for 18 days from seeding under white (broad spectrum) light emitting diodes under sole source light in environment controlled growth chambers. Growth chamber temperature was 23 °C and a light intensity of 185–200 μmol·m⁻²·s⁻¹ with a 24-h photoperiod was provided. At 18 days, the light source was switched to cool white fluorescent (CWF) fixtures providing continuous light at 185–200 μmol·m⁻²·s⁻¹ for 48h. Anthocyanin and chlorophyll concentration, and expression of anthocyanin pathway genes were measured. Following shift to CWF, leaf color gradually became darker red over time. The CWF spectrum stimulated the biosynthesis of total anthocyanin and chlorophyll a/b-binding proteins genes using real-time PCR. Anthocyanin biosynthesis genes (CHS, DFR, ANS and UFGT) and chlorophyll a/b-binding proteins genes (Lhca1-4 and Lhcb1) exhibited increased expression in response to CWF. While pigment accumulation, also tended to increased over time, response lagged several hours behind gene expression. Interestingly, while the experiment was conducted with continuous lighting, a pattern of 24 h oscillations in gene expression were evident suggesting that genes responsible for pigment accumulation were regulated by both light treatment as well as circadian rhythm. Our findings help elucidate the role of the chlorophyll and anthocyanin pathway genes in response to light spectrum and suggest further study to understand the involvement of circadian clock genes in the regulation of anthocyanin and chlorophyll pathways.

Specified Source(s) of Funding: NYSERDA GLASE

Selecting High-quality Head Lettuce for Greenhouse Production under Differing Supplementary Light Sources (*Poster Board #148*)

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Variety testing of vegetables is an important step for beginning businesses to narrow down product focus, generate example product for potential customers, and determine performance of varieties under one’s own environmental conditions. Greenhouse grown lettuce has a reputation of being more tender, having grown with fewer environmental stressors, than field grown counterparts. Greenhouse lettuce receives a shifted spectrum of light than outdoor plans due to solar interception by greenhouse glazing materials, which can lead to differences in plant morphology. High pressure sodium (HPS) fixtures are currently the most commonly used supplemental lighting source in greenhouse lettuce production. The introduction of light emitting diodes (LEDs) into the greenhouse industry can allow growers to adjust light spectrum and potentially alter plant morphology, biomass, pigmentation, and development of the physiological disorder, leaf tip burn. The objective of this experiment was to determine response of 13 varieties of head lettuce to greenhouse performance under HPS or LED light. Lettuce was grown from seed in a common area until seedlings had 3-4 true leaves. Seedlings were then transplanted into a split nutrient film technique (NFT) system with two lighting arrays could share the same greenhouse but avoid light pollution between treatments. One lighting array used HPS fixtures while the other array had LEDs set to a fixed red:blue ratio (80% red : 20% blue). Both arrays were adjusted to provide a spectrum, we examined the expression of anthocyanin and chlorophyll a/b-binding proteins genes using real-time PCR.
similar light intensity of about 200 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}, which had been split in half. Quantum sensors were placed under each lighting array and were connected to a microprocessor which used the LASSI (Light and Shade System Implementation, Albright et al., 2010) control algorithm to adjust the daily supplemental lighting period to complement ambient light to achieve a fixed daily light integral (17 \text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}). Data were collected on plant fresh weight and tip burn index. Qualitative data were collected on taste, color, and texture. Four cultivars exhibited a significant response (P ≤ 0.05) to light source: ‘Lotus’, ‘Seurat’, ‘Teodore’, and ‘Xandra’. Three additional cultivars had a moderate response (P ≤ 0.10) to light source: ‘Crunchita’, ‘Greenstar’, and ‘Rex’. For these seven cultivars fresh weight under LED was less than HPS. Qualitatively, several varieties were found to have an unacceptable bitter taste. In some cases, taste varied between the HPS and LED grown plants. Regarding leaf color, red leaf varieties showed greater red pigmentation when grown under the LED array.

*Specified Source(s) of Funding:* NYSERDA GLASE

**Warm and Cool Full Spectrum LED Supplements Impact Key Flavor Volatiles in Hydroponically Grown Basil** *(Poster Board #149)*

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Blue (B) and red (R) wavelengths within the photosynthetically active radiation (PAR) spectrum drive primary metabolism in plants. Spectral quality is an important factor in greenhouse production and directly impacts plant growth and development. Light emitting diodes (LEDs) offer excellent spectral control and allow growers to optimize biomass yield and plant quality throughout growing seasons. Full spectrum white LED lights are becoming popular for commercial production of high value specialty crops, but research is needed to determine the impact of warm and cool full spectrum supplemental lighting in comparison to narrowband B/R LEDs on secondary metabolism and flavor volatile production. The objective of this study was to establish impacts of full spectrum LEDs and narrowband B/R LEDs on key flavor volatiles in hydroponic basil (Ocimum basilicum var. Italian Large Leaf). A total of four treatments were used: warm white LEDs (3200 K), cool white LEDs (5600 K), 20B (447 nm)/80R (627 nm) narrow band LEDs, and one non-supplemented natural light control. Each supplemental lighting treatment provided 150 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} for 24 h. The daily light integral (DLI) of the natural light control averaged 9.8 \text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1} during the growth period (ranging from 4 to 20 \text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}). Relative humidity averaged 55%, with day/night temperatures averaging 29.8 °C/23.6 °C, respectively. Basil plants were grown in a closed gutter hydroponic system with standard fertility regimen and harvested 45 d after seeding. Flavor volatile compounds were quantified using GC-MS.

Concentrations of key flavor volatiles varied significantly across lighting treatments. Eucalyptol, linalool, limonene, \beta-myrcene, and \alpha/\beta-pinene showed increased concentrations under the 3200 K LED treatment in comparison to the 5600 K LED treatment. With the exception of methyl eugenol, all compounds evaluated were significantly higher in LED treatments as compared to the natural light control. Concentrations of some undesirable flavor compounds, such as dimethyl sulfide and benzaldehyde, followed a similar trend as many of the evaluated compounds, with increased concentrations found in the 3200 K LED treatment in comparison to the 5600 K treatment and natural light control. In general, plants under the full spectrum treatments showed increased VOC concentrations than plants under the 20B/80R treatment, suggesting that fluence and spectral quality influence secondary metabolism. The results of this study show that full spectrum LEDs can manipulate secondary metabolism and flavor volatile production in basil, making the selection of LED spectral quality critical to maximize quality.

**Optimizing Spectra for Mizuna Grown on International Space Station** *(Poster Board #150)*

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Astronaut diets on the International Space Station (ISS) consist of resupplied, packaged food. However, missions to Mars of 3–5 years, will not accommodate re-supply. In addition, many human macro and micro nutrients decrease during long-term storage. Thus, growing plants aboard ISS is essential for providing astronauts with fresh, healthy produce. Thus, NASA is testing an experimental vegetable production unit called VEGGIE to grow fresh salad crops aboard ISS to provide astronauts with healthy diets. VEGGIE is a small plant growth chamber designed as a garden for astronauts that is low in mass and has a low power requirement. Veggie is equipped with light emitting diodes (LEDs) but is exposed to the ISS cabin environment. Plants initially were grown with roots in plastic “pillows” containing baked-ceramic substrate incorporating controlled-release fertilizer and a wick delivering water by capillary action from a reservoir. NASA is testing a next-generation growth unit for VEGGIE called PONDS, consisting of a cylinder with gas-permeable interfaces and capillary-mat slots. The Purdue Mitchell lab in collaboration with NASA is testing growth of salad crops in PONDS within VEGGIE analogs under ISS environments. Specifically, we are evaluating effects of light spectrum and fertilizer treatments on “cut-and-come-again” productivity and quality of Mizuna. ISS environments being tested include 24/21° C D/N, CO₂: 2800 PPM, RH: 45 to 50% D/N, and photoperiod: 16 h. Arcillite growing mix with 15 g/L of 18–6–8 T 70 fertilizer. LED Light treatments provide total intensity of 330 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} PAR; with different red(B): green(G) ratios. Our treatments are 270R: 30B: 30G, 210R: 90B: 30B, and 150R:150 B: 30G. Plants are grown under those conditions for 8 weeks, and harvested five times at 28, 35, 42, 49, and 56 days. Currently we have our experiment running, and we will have our first harvest in two weeks.

An asterisk (*) following a name indicates the presenting author.
History of Horticultural Science (Poster)

The Downward Trend in Post-secondary Horticulture Programs between 1997 and 2017 (Poster Board #088)

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Over the past several years, horticulture programs appear to have experienced a decline in undergraduate enrollment or have been eliminated completely. The scale of this phenomenon remains to be quantified and characterized. In order to determine the accuracy of these observations and identify existing trends, we compared post-secondary horticulture educational programs offered in the United States in 1997, which issued certificates and 2- and 4-year degrees, with those offered in 2012 and 2017. Sources for the 1997 data included college blue books, state horticulture-related associations, and local industry professionals. Data for 2012 were obtained through an internet search and phone calls, while the 2017 data were obtained through internet searches only. In 1997, 446 schools in the United States offered degrees and/or certificates in horticulture. In 2012, this number had decreased by 43% to 253 schools, which consisted of 98 offering 4-year-degree-, 215 offering 2-year-degrees, and 300 offering certificate programs. In 2017, the total number of schools offering horticulture-related degrees or certificates decreased to 209, which represents a 17% decrease from 2012. All considered, in 2017 85 schools offered four-year degrees, 133 schools offered two-year degrees, and 265 schools offered certificate programs. These represent a 13% decrease, 38% decrease, and 29% decrease between 2012 and 2017 for schools offering 4-year, 2-year and certificate programs, respectively. Overall, these findings indicate a 53% drop in the number of schools with horticulture programs between 1997 and 2017. The trajectory toward the elimination of 2-year and certificate programs is of particular concern for industries and agencies that rely on horticultural knowledge to satisfy workforce needs.

Specified Source(s) of Funding: Brigham Young University

Invasive Plants Research (Poster)

Comparisons of Growth and the Effect of Substrate Fertility on North American and Eurasian Lonicera caerulea and the Invasive Lonicera tatarica (Poster Board #167)

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The sale and planting of many Eurasian honeysuckles (Lonicera spp.) is largely discouraged within the horticulture industry of North America. Increasingly, states legislatures have sought to ban the sale of Lonicera and other nonnative, invasive plants from commerce. A notable exception is the recent introduction of various cultivars of honeyberry (Lonicera caerulea) of Eurasian origin into the North American market, where they may have value in landscaping and as a berry crop. Because honeyberry is already listed as a serious invader of boreal forests in Norway, we decided to assess the potential competitive ability of honeyberry in a North American context by comparing the growth of rooted cuttings in containers to the growth of both mountain fly honeysuckle (Lonicera caerulea var. villosa), a diminutive, ecologically rare conspecific native to North America, and Tatarian honeysuckle (Lonicera tatarica), an invasive congener. We grew cuttings of each in a peat-based substrate in #1 nursery containers, which were top-dressed at the start of the experiment with Osmocote Pro 17-5-11 4-month controlled-release fertilizer (CRF) at rates of 5, 10, 15, 20, and 25 g/container. After four months, Tatarian honeysuckle produced the greatest dry biomass, with nearly five times the shoot dry weight (SDW) and root dry weight (RDW) of honeyberry, which in turn produced about twice the SDW of mountain fly honeysuckle. SDW of Tatarian honeysuckle exhibited a strong response to increased substrate fertility, producing more than twice the SDW when fertilized with 20 grams than with 5 grams of CRF. Neither mountain fly honeysuckle nor honeyberry displayed a significant SDW response to increasing CRF application rates, indicating they may be less able than Tatarian honeysuckle to quickly respond to flushes of substrate fertility. Although honeyberry produced only one-fourth the RDW of Tatarian honeysuckle, it produced between two to three times the RDW of mountain fly honeysuckle. Finally, honeyberry rivalled Tatarian honeysuckle in cumulative length of primary stems, far exceeding that of its conspecific, and oriented more toward rapid vertical growth. Despite the classification of mountain fly honeysuckle and honeyberry within a single circumboreal species complex, honeyberry produced several measures of growth that were at least double those of mountain fly honeysuckle, a finding that suggests the two taxa may not be ecologically equivalent. We recommend further comparative studies between honeyberry and its native and invasive congeners in North America, to clarify the relative risks and benefits of its cultivation.

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Organic Horticulture (Poster)

Living Soil for a Sustainable Future: Cover Crop Effects on Soil Health and Productivity (Poster Board #219)

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**Poster Presentations**

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Agricultural land management influences the physical, chemical, and biological characteristics of soil, including the structure of the community of soil microorganisms. In turn, the community of soil microorganisms directly influences processes such as nutrient cycling and water infiltration and retention, which shape the long-term fertility and productivity of the soil. The purpose of this study was to examine the effects of cover cropping on the soil biological and chemical features that contribute to soil fertility. The study looked at two summer cover crops—cowpea (*Vigna unguiculata*) and sorghum-sudangrass (*Sorghum bicolor*) in comparison with no-cover control—and their effects on soil respiration, soil organic matter and nitrogen availability, and fall lettuce production under black plastic mulch. Using soil samples taken from the in-field experiment, a parallel laboratory aerobic incubation study examined the effects of the cover crop on the transformation of nitrogen over five weeks. Both cover crops increased soil organic matter, total organic carbon, potassium, and magnesium by over 20%, 21%, 27%, and 35%, respectively, compared to the no-cover crop control. There were no differences in C/N ratio. Cowpea increased extractable soil nitrate by 97% and soil respiration rate by three fold compared to the no-cover control. In contrast, sorghum-sudangrass decreased extractable soil nitrate concentration to 21% of the control no-cover, but the increase in respiration was not different from the control. Lettuce growth and production as measured by both fresh weight and leaf area were reduced after sorghum-sudangrass, but were not different between cowpea and the control. In conclusion, the study found that sorghum-sudangrass and cowpeas both increased soil organic matter, but only cowpea increased inorganic N, and that sorghum-sudangrass was detrimental for fall lettuce production under plastic mulch in the Eastern Shore of Virginia.

**Specified Source(s) of Funding:** Southern SARE

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**Low Tunnels Provided Frost Protection and Increased Yield of Organically Managed June-bearing Strawberries in Field Production** (Poster Board #220)

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Using protected agriculture such as low tunnels can provide a substantial amount of plant protection during frost events. Cold damage to strawberry flowers and fruits occurs when temperatures are below 32 °F, which could result in yield loss throughout the season. The objective of this 2-year study (2016–17 and 2017–18) was to investigate if low tunnels would provide frost protection and increase yield of organically managed June-bearing strawberries in the annual plasticulture system. This study was conducted at the North Carolina Agricultural and Technical State University research farm in Greensboro, North Carolina (hardiness zone 7). June-bearing varieties were Benicia, Camino Real, Florida Radiance and Winterstar. Low tunnels consisted of metal wire hoops covered with 1mil perforated plastic. The experimental design was a completely randomized design (CRD), conducted as a splitplot with three replications. The main plots were beds covered with low tunnels (LT) or without low tunnels; the split plots were cultivars. All strawberry plants experienced cold damage to flowers and fruit from December to March each season. Low tunnels were able to provide some degrees of frost protection in both years. In the 2016–17 season, damage to open flowers in December was 22% more with LT than without LT. In January, there were a lower number of fruits and flowers present at the time and no significant differences between the treatments existed. In February, less flowers were damaged with LT (8.6%) than without LT (10.5%). In the 2017–18 season, flowers and fruit damages to frosts were 22.7% and 8.7% with LT and 41.3% and 57.2% without LT, respectively. The frost protection by LT resulted in increased strawberry yield. In the 2016/17 season, the marketable yield in March was 20.45 g/plant with LT compared to 12.05 without LT; and in April, the number were 141.94 and 129.45 respectively. LT also reduced cull yield, for example in May 2017, the cull yield was 70.3 g/plant with LT and 97.7 g/plant without LT. Our results indicated that LT can significantly increase marketable yields of organically managed strawberries by protecting plant, flowers and fruit from cold damages in the field.

**Using Tarps to Reduce Tillage in Small-scale Organic Beet Production** (Poster Board #221)

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Interest in using impermeable black tarps has increased among farmers. Tarps offer a low-cost option for small scale farmers to prepare land in a reduced or no-till system. Tarping can be used in place of tillage for weed control and cover crop reduction. Tarps also change the soil environment by altering moisture content and temperature effecting soil N mineralization. In 2017 Research was carried out at the University of Maine Agricultural and Forestry Experiment Station: Highmoor Farm in Monmouth, ME. Two target planting dates were determined, each consisting of four different tarping durations (long, 6 week, 3 week and no tarp) and three tillage treatments: full-till (6 inches); shallow-till (2 inches); no-till laid out in a split-block design. Tarps were placed overwinter 24 weeks before planting 1, 10 weeks prior to planting 2, and then 3 or 6 weeks prior to both plantings. Tarps were placed over an oat cover crop for the overwinter treatment and the cover crop residue for the remaining treatments. Upon tarp removal and prior to tillage, weed and cover crop residue were assessed and soils were sampled for nitrogen (NH$_3$N and NH$_4$N). ‘Boro’ beet (Beta vulgaris) was then planted by hand. No weeding was performed in any of the plots. Just prior to harvest weed assessments were made and weed biomass was determined. A once-over harvest was made when greater than 50% of the crop reached a diameter exceeding 0.75 inch. Harvested beets were graded by size and quality and then counted and weighed. Tarping significantly increased marketable yields in both plantings. Tillage intensity, deep, shallow or no-till had no effect on marketable yield in either planting of tarped plots. However, in plots without tarps or tillage yields were significantly lower. NH$_3$N levels increased in planting 1 with tarps, although not significantly. In planting 2, NO$_3$N levels significantly increased with tarping period while NH$_4$N levels were significantly lower under tarps. Weed cover immediately after tarp removal was significantly lower in all tarping treatments compared to no tarp; while, cover crop residue was similar between tarping lengths. Weed biomass at harvest was significantly greater in plots without tarps and tillage in both plantings.

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Growing High Tunnel Use for Organic Vegetable Production in the Southeast (Poster Board #222)

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Stakeholder-driven organic high tunnel systems research in the Southeast is lagging behind what has been investigated for cooler climates. Organic vegetable growers in humid sub-tropical climates would benefit from research evaluating how to optimize these protected culture systems in a way that integrates improved crop performance and resilience, environmental stewardship, and economic viability. The objective of the project was to identify critical research needs for developing integrated high tunnel systems to promote the growth and expansion of organic vegetable production in the Southeast. We began by completing in-depth interviews with a panel of organic producers with extensive experience using high tunnels. Collaborators on the project provided a roster of ten farmers and personnel at the University of Florida completed in-depth interviews with eight. We presented the findings at the first meeting involving the stakeholder representatives in Oct. 2016. After an extensive discussion, we identified six related sets of decisions that organic high tunnel users must make and for which there are few, if any, science-based recommendations. These are: 1) decisions about the cropping system (crop selection, cover crops, and crop rotations); 2) management of the high tunnel environment through ventilation and heating; 3) soil and nutrient management; 4) pest and disease management; 5) economics; and 6) attracting pollinators and beneficial insects. We summarized our understanding of the major needs expressed by the expert panel and sent a short questionnaire to the panel members. We asked them to rank the six broad topical areas in terms of importance as an area for research and identify the three most important crops to include in the research. This verified our interpretation of what growers indicated in the interviews and made sure we reached valid results about their needs and priorities. They provided two points of clarification. First, pollinators and beneficial insects are a subset of the general topic of pest and disease management. Second, economic issues are specific to each of the key decisions that growers make and are a major factor in assessing the biological research. We then developed and distributed a questionnaire to organic vegetable growers using high tunnels in Florida and Georgia. We asked respondents to rank specific research topics on a scale of 1 (not at all important) to 5 (extremely important). The findings will direct our research objectives in future high tunnel projects focused on improving organic vegetable production and management.

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Integrating Row Covers into Organic Production Systems for Leafy Green Vegetables (Poster Board #223)

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Row covers are gaining interest in crop production to improve growth and yield in different agricultural climates and production

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Fertigation is an effective method to quickly deliver nutrients to crops, matching application timing with crop needs. Organic fertilizers can be expensive, especially for fertigation. In this study, commercially available fertilizers in small quantity (e.g. up to 1 gallon for one-time purchasing) and bulk-quantity (e.g. > 256 gallon) in the United States were tabulated, and cost per unit (lb) of nitrogen (N) was calculated. The price of N per lb varied significantly between fertilizers within the two categories. For fertilizers sold in small quantities, the cost per lb of N ranged from $13.27 to $269.50. For fertilizer sold in bulk, the cost per lb of N ranged from $8.70 to $36.00. Other considerations for selecting an organic fertilizer for fertigation include solubility, viscosity, and other characteristics that can impact the ease of injecting the fertilizer solution as well as drip tape maintenance (clogging of emitters). Thus, costs for labor and supplies associated with injection and maintenance must also be considered. Another consideration is the odor of the fertilizer, as many soluble organic fertilizers are fish-based. Especially when applied in confined spaces (e.g., tunnels or greenhouses), the odor may have a negative human impact. The amount of time to apply three different organic fertilizers will be presented, and the risk of clogging the drip line and emitters will be discussed.

The three fertilizers selected for this study were: 1) fish-based and low price per lb N, 2) corn-based, 3) fish-based and commonly used in our region.

**Seed and Stand Establishment (Poster)**

Non-deep Simple Morphophysiological Dormancy in Seeds of *Lonicera subsessilis* Rehder (Caprifoliaceae), an Endemic Species in the Korean Peninsula (Poster Board #192)

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*Lonicera subsessilis* Rehder, which belongs to the Caprifoliaceae, is located in the Baekdudaegan area, ranging from Pyeongangnam-do to Jeollanam-do in the Korean peninsula. *L. subsessilis* is generally known to grow up to 2 meters tall, has high density of the branches, and the rich green leaves and the autumn ripe fruit is attractive. So they are highly valuable for ornamental purposes. In order to utilize the *L. subsessilis*, a sufficient quantity of materials should be supplied to ensure their stability. This experiment was carried out with the goal for developing mass production protocol. The seeds used in the experiment were collected from plants growing the Korea National Arboretum in Pocheon on 26 May 2017. The seeds were sown in field soil in an experimental garden. Every two weeks, seeds were exhumed, and phenology of embryo growth, germination, and seedling emergence was observed. Temperature requirements for germination were also determined by incubating seeds under controlled laboratory conditions. As a result of the inhibition experiment, seed fresh weight increased by approximately 91.3% over the previous 24 hours. At the time of seed disposal, *L. subsessilis* has underdeveloped embryo (about 11.3% of seed length). In seeds incubated at 5, 15, 20, and 25 °C, germination percentage was 0, 80.0, 85.6, and 76.7% at 27 weeks after sowing, respectively. Most of the seeds incubated at 15 and 20 °C germinated within 12 weeks, whereas the seeds incubated at 25 germinated within 25 °C weeks. In the move-along test [summer start: 25 (12 wk) → 20 (4 wk) → 15 (4 wk) → 5 °C (12 wk) or winter start: 5 (12 wk) → 15 (4 wk) → 20°C (4 wk)
25 °C (12 wk), summer and winter start seeds started to germinate at 15 and 25 weeks after sowing, respectively. And the final germination rate for each treatment was 83.3% at 17 weeks, and 83.3% at 30 weeks, respectively. The result indicates that germination was promoted at a relatively warm temperature (15 to 20 H₂SO₄ °C). Therefore, the seeds expressed non-deep simple morphophysiological dormancy (MPD).

Sulfuric Acid Breaks Physical Dormancy in Seeds of Lespedeza tomentosa (Poster Board #193)
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Lespedeza plants can be resource plants that are used for livestock feed and embankment greening. These seeds are known as fire-activated species that germinate after the fire in the mountains. In previous studies, germination occurred when heat was applied to seeds, but germination rate was low and treatment was not easy. Therefore, this study was carried out in order to increase the germination rate of L. tomentosa by chemical scarification with sulfuric acid. Seeds were soaked in 98% sulfuric acid for 0, 1, 3, 6, 12, 24, 48, 96, 192, and 384 minutes and washed in distilled water for 24 h. Very few seeds were germinated in control (H₂SO₄ for 0 minutes). More than 90% of seeds were germinated in H₂SO₄ for 24, 48, and 92 min. However, some damage was observed in roots and cotyledons of seedling dipped in H₂SO₄ for a long time. To search the optimal soaking time in H₂SO₄ without defects, seeds scarified in H₂SO₄ for 30, 60, 90, 120, 150, 180, and 300 minutes were sown the commercial soil substrate. Seeds treated with H₂SO₄ for 90 minutes and 150 minutes emerged by about 92% and 84%, respectively. Therefore, the optimal time of sulfuric acid for germination of L. tomentosa is estimated to be 1–2 h. The germination was completed within one month after germination began immediately after the seed treatment so that the seed of L. tomentosa had physical dormancy without physiological dormancy.

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Effects of Water Stress and Cold Treatments on the Germination of Two Conifers (Pinus nigra and Pinus brutia) Species from Turkey (Poster Board #194)
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Determining the establishment success of a tree species requires conducting germination tests before using it in extensive horticultural programs. This is particularly critical in cold, arid or semi-arid climates where there is little or no top-soil. In the study, the germination performance of five Turkish red pine (P. brutia Ten.) provenances and one black pine (P. nigra subsp. nigra) provenance from Turkey were investigated after exposure to artificial cold temperature and water stress treatments. Cold treatments to decreasing temperatures (0, −5, −10, −15, −20 °C) were conducted in an artificial freezer (ScienceTemp model 40-12A, Adrian, MI). The seeds were then sown in a Styrofoam block in a greenhouse where germination rate, speed, and other parameters were determined. Water stress treatments were conducted using polyethylene glycol (PEG) at five different osmotic potential levels (control, −0.2, −0.4, −0.6 and −0.8 Mpa). Seeds were placed in a germination room and the experiment was carried out at 25 ± 1 °C under 12-h photoperiod. Germination counts were performed daily for 30 days and was determined to have occurred if the radicle protruded 2mm from the seed coat. In general, decreasing temperature decreased the germination rate. Antalya-Gundogmus provenance showed the significantly lower germination difference compared to other provenances in each temperature treatments. Higher osmotic potential decreased the germination rate. Control treatment had significantly higher germination rate compared to all other water stress treatment. P. nigra was significantly different compared to P. brutia provenances in control treatment. Results have strong horticultural implications for understanding the effects of water stress and temperature on germinations rates.

Teaching Methods (Poster)
Produce Department Inventory and Analysis: Value for Hort 310 “Pomology” Students at Washington State University (Poster Board #341)
Desmond Layne*
Auburn University, Auburn, Alabama, United States

HORT 310 “Pomology” is an undergraduate course focused on temperate-zone tree and small fruit crops with an emphasis on practices utilized in the Pacific Northwest. The course is required for students in the Fruit and Vegetable Management major of the Integrated Plant Sciences interdisciplinary program. Other majors that typically take the course include Viticulture and Enology and Organic Agriculture Systems. Each year, at least 25% of the enrolled students are pursuing either a MS or PhD degree. Besides the traditional elements of a pomology course, a strong emphasis is placed on management practices to ensure grower profitability and presenting a high-quality product to the consumer. Whether fruits are produced in the United States or some other country, students are expected to know the diversity of available fruits, where the fruit are coming from, how they are marketed, packaged and priced in the local commercial chain-store. The course focuses on general pomological concepts in the first several weeks and then the focus
Demonstrating the Allelopathic Effect of Horseradish Extract on Lettuce Seeds for Undergraduate Student Lab (Poster Board #342)

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Kang-Mo Ku
West Virginia University, Morgantown, WV, USA

Allelopathy plays crucial roles in invasive plant viability and agricultural production systems. However, there is no well-established hands-on learning activity to teach the concept of allelopathy. Nor is there an activity which allows students to gain knowledge about glucosinolates and their corresponding enzyme, myrosinase, which are present in almost all brassica crops. This study explores an inexpensive and easy allelopathy laboratory activity for undergraduate students majoring in chemistry, biology, agronomy, and/or horticulture. Students were split into groups throughout the experiment. Lettuce germination was counted from three different treatments including water-treated, horseradish-treated with Parafilm sealing, and horseradish-treated without Parafilm sealing 22 hours after seed sowing by the students. Additionally, lettuce root length was measured by students using ImageJ software from each treatment using pictures captured by students’ smartphones. Students took an identical quiz as a pre-lab and a post-lab as assignment. Their average scores on the pre and post-lab quizzes were 3.2 and 6.5 out of 10, respectively, indicating the lab activity improved students’ understanding of allelopathy and glucosinolate-myrosinase system. In addition, students (n = 76) completed a survey post-lab to assess their self-efficacy. A vast majority of students agreed “I can utilize a smartphone to collect data for plant science experiment” (88%), “The experiment was designed to improve my knowledge on allelopathy” (84%). This simple and cost-effective lab activity was very helpful as it made learning more inviting, meaningful, and fun.

Developing a Hands-on Class to Increase Student Awareness of Florigicultural Arts in Hawaii (Poster Board #343)

Teresita Amore*
Tropical Plant and Soil Sciences, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, HI, USA
Orville Baldos
University of Hawaii at Manoa, Honolulu, HI, USA

The floriculture and nursery industry is one of the most profitable agriculture sectors in the state of Hawaii. Despite its economic importance, fewer and fewer people opt to pursue a career in this field. To increase awareness and recruit students in floriculture, an experimental class to introduce the principles and techniques of floricultural arts was developed at the University of Hawaii. The course was designed to: 1) acquaint students with the different aspects of floral design/floristry; 2) provide hands-on experience on making different floriculture products; and 3) provide opportunities to design and develop new floriculture products. The course consists of a 1-hour lecture and a 3-hour hands-on lab. Students learned to forage for and prepare plant materials, press and dry flowers and foliage, as well as design and construct flower bouquets, garlands (leis), botanical jewelry and pressed flower art. Students were also challenged to include native Hawaiian plants in their design. Selected designs were photographed and displayed in a month-long exhibit at the university library. A listing of plant species accompanied each art piece, to educate the viewing public on design possibilities of using various common and underutilized plant materials. Feedback on the public exhibit was positive and generated interest in plant-based arts. As a final project, students prepared table centerpieces for the College’s awards banquet. For each activity, students submitted a report that included a photograph of the completed project, with a listing of both common and scientific names of the plant material and its usage. At the end of the semester, the project portfolio was graded on completeness and accuracy. Students were asked to write a reflection paper to assess which activities were beneficial in applying the principles and elements of design. Feedback from the students will be utilized to institute a new course that will cater to non-majors.

Specified Source(s) of Funding: Hawaii Dept. of Agriculture NEWGERMLASM grant (funded in part)

Lecture and Laboratory Curricula Influence College Student Knowledge and Attitudes Regarding Invasive Species (Poster Board #344)

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Paula Williamson
Texas State University, San Marcos, TX, USA

An asterisk (*) following a name indicates the presenting author.
Using Zoom for the First Time in a Scientific Communications Course (Poster Board #345)

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TPSS 654 Communications in the Sciences is a required one credit, two hours a week graduate course covering various aspects of scientific communications. In Fall 2017, a student asked the instructor if an online Zoom option might be available. As a parent of several young children and an hour and a half commute to the university, getting to school was not an easy task. To help students become more educated about invasive species, the instructor implemented a literature review project in a greenhouse production course. This opportunity for off campus students, was a unique experience, added diversity to the class.

An asterisk (*) following a name indicates the presenting author.
content, writing summary papers, and discussing the articles. The objectives were to increase students’ confidence in and ability to critically analyze primary literature, formulate practical recommendations from the literature, and communicate those recommendations to industry professionals. To assess the effectiveness of our primary literature review project, we administered a series of ten pre- and post-reading surveys to track student content knowledge and student confidence over the semester. We also analyzed the article summaries based on a rubric emphasizing the importance of providing accurate, complete, and practical recommendations to a greenhouse industry professional.

Specified Source(s) of Funding: Michigan State University Future Academic Scholars in Teaching (FAST)

**Student Perceptions of Lecture Capture in an Introductory Face to Face Course**

*(Poster Board #347)*

Bruce Dunn*

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Use of lecture capture technology has increased in the last decade to enhance the student learning environment, yet is still not used in the majority of courses at most institutions. Lecture capture is used to describe any type of system, where the content of a lecture is recorded for dissemination to students at a later date. The purpose of this study was to evaluate the perceived benefit of having recorded lectures and labs by surveying students in a 1000 level Principles of Horticulture class over two semesters. Student were given access to previously recorded lectures and lab along with lecture slides through the course Desire to Learn platform. At the end of the semester, students were given a paper survey with 10 likert type questions related to use along with student demographics. Of the 92 students who responded to the survey, all student classifications were represented almost equally and ranged from 20% freshman to 30% juniors and 18% considered themselves commuters. Results of the survey showed that the majority (55%) viewed some of the recorded lectures or labs and only 31% viewed both lecture and lab videos. Eleven students did not indicate that having access to recorded videos was useful and may have instead preferred the presentation slides. Only a small percentage (5%) of the students indicated that they preferred to view recorded lectures instead of attending class.

**Enhancing Student Learning through Transparent Assignment Design**

*(Poster Board #348)*

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With an ever-increasing number of “first gen” (e.g., first generation in their family to attend college) students attending Land-Grant universities, teachers are being challenged to find ways to both effectively reach/teach these students and assess their learning. There is strong scientific evidence supporting the idea that by taking simple steps to make assignments more “transparent,” not only “first gen” but all students can benefit. A simple concept referred to as “transparent assignment design” can be used to improve student learning. There are three key parts to a “transparent” assignment. These include purpose, task, and criteria. A clearly written purpose helps students to understand how the assignment is linked to their learning, the skills they will practice, knowledge that will be gained, relevance to their life and connection to the learning objectives of the class. The task clearly defines what the students will do and how they will do it. This can include steps that they should follow and things they should avoid. The criteria for success can include a checklist or rubric from which the assignment will be graded. It can also include an annotated example of previously graded student work (used with permission, student names redacted) from the past to show what excellence or “A-grade” final product looks like.

In Fall, 2017, teaching faculty from the Agriculture and Food Systems and Integrated Plant Sciences interdisciplinary programs at Washington State University were invited to attend a facilitated workshop-retreat focused on “transparent assignment design.” Faculty were prompted to bring assignments that they were already using in their classes. Following instruction about the concept, review of before-and-after examples, and discussion, faculty were assembled into pairs to work together and help each other to make their assignments more transparent. Faculty response to the workshop was determined afterwards by an on-line survey. By way of example, for the HORT 310 “Pomology” course, a comparison of both the assignment and representative student work before (2016 class) and after (2017 class) the assignment was made transparent will be compared and contrasted. Assignments that are revised to be more transparent need not be any less rigorous than their former version. However, when they are developed and deployed properly, they can help to enhance student learning and result in higher quality student work that is easier and faster to grade.

**Increasing Experiential Learning and Student Participation through Poinsettia Fundraising Sales: Lessons Learned from the 2017 Season**

*(Poster Board #349)*

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A critical component of an education in horticulture is hands-on experience growing plants. There are limited opportunities for
students in the Department of Tropical Plant and Soil Sciences (TPSS) at the University of Hawaii to gain this experience, and if the opportunities available are voluntary, it can be difficult to achieve good participation from students. Multiple plant sales are held by the TPSS Graduate Student Organization (GSO) and the undergraduate Horticulture Society throughout the year for holidays such as Valentine’s Day and Christmas. In 2016, students started growing the plants instead of purchasing them from local wholesale nurseries for resale, resulting in higher quality plants and very successful plant sales. However, there is still ample opportunity to increase real world experience for horticulture students and for students to gain mentoring experience and leadership skills. Therefore, students doubled production amounts from 200 plants in 2016 to 400 plants in 2017. Additional cultivars were grown for the 2017 poinsettia sale, with three traditional poinsettia cultivars added to the four Princettia hybrids grown. A TPSS Special Topics class created in Fall 2017 to teach students about poinsettia production and marketing increased student participation in the project. Finally, a trial pre-sale at the production greenhouse facility was conducted, in addition to increased advertising and new marketing strategies. The pre-sale and regular campus sale were very successful, with 97% of the 400 plants sold. This resulted in nearly $3000 in revenue for the students to use for team building activities, social events, and travel to scientific conferences. Customers were impressed with the quality of the plants. Collaboration with the Special Topics class was worthwhile, with students participating in major production, marketing, and sales activities. Production will be further expanded for the 2018 season, with plans to add more traditional red poinsettias due to customer demand. A collaboration with a TPSS Horticultural Practices class is planned to involve more students in Fall 2018. Advertising at off-campus sites will be added to increase traffic at the greenhouse pre-sale. Finally, students gained valuable growing, marketing, leadership and mentoring skills in addition to a strong sense of pride and accomplishment. We thank Dümmen Orange, Suntory Flowers, Delilah Onofrey, Angela Mekjian, Craig Okazaki, and Ronald Matsuda for their assistance.

**Poinsettia Nursery Production: Horticulture Lab Experiential Learning Activity**  
*Poster Board #350*

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Florida International University, Miami, FL, USA

Students from the horticulture science lab at Florida International University (FIU) had the opportunity to gain hands-on experience in the growing and marketing of plants through poinsettia production for the Third Annual Poinsettia Sale event at FIU. Approximately 500 rooted poinsettia were acquired from the local nursery, transplanted, pinched, fertilized and treated with the plant growth regulator (PGR) B-Nine as part of the production process.

**Use of the MSU Community Garden for Teaching, Research, and Outreach Programs**  
*Poster Board #351*

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Cory Gallo  
Mississippi State University, Mississippi State, MS, USA

A case study was conducted to investigate the use of the Mississippi State University (MSU) Community Garden as a living classroom for teaching, research, and outreach programs. The Mississippi State University Community Garden initiated its first planting in Apr. 2017. Designed by associate professor Cory Gallo’s landscape architecture design/build studio, twelve raised beds were designed and built in the garden in 2017. Construction of the MSU community Garden is planned to be complete in 2018 with a total number of 30 raised beds and an orchard. From a teaching standpoint, three courses including the Gardening Experience (PSS 1113), Grow Your Own Salads and Soups: Vegetable Gardening (LA 1001), and Community Food Systems (LA/PSS/FNH 4990/6990) are using the community garden as experiment site, where students gain hands-on experience of growing vegetables. At the MSU Community Garden, students can volunteer to work in the garden and serve as creative outlets for them. The Community Garden also serves as a base for graduate and undergraduate student research. The garden will provide demonstrations of new and sustainable gardening practices and be available to student, staff, and faculty members in MSU and to Starkville citizens. The community garden provides opportunity to involve people of all ages in promoting inspiration for gardening and a sense of pride in the work that is accomplished there. Therefore, the community garden is making an impact for people in and outside MSU by increasing health consciousness of the community and promoting a healthy local food system.

**Enhancing Student International Learning Experiences through a Study Abroad Exchange Program in Tropical Horticulture**  
*Poster Board #352*

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Katrina Spillane  
Universidad Nacional de Agricultura, Catacamas, Honduras

An international academic partnership between Louisiana State University (LSU) and the Universidad Nacional de Agricultura (UNAG) in Honduras was strengthened by a Partners of the Americas-funded study abroad program. The main activities included a one-week tropical horticulture field study course in Honduras for LSU and UNAG students, followed by a three-month visiting scholar program at LSU for five UNAG students. The study abroad course provided some of the most impressionable horticulture-related learning experiences for all student participants and fortified their career interest in horticulture. It also gave LSU students the opportunity to see crops that do not
grow in the continental United States and understand the entire value chain from production through marketing. The visiting scholar program developed UNAG student competencies in field and laboratory research from faculty and staff-supervised training. It also provided U.S.-university classroom learning experiences in a diversity of horticulture-related subjects. The most outstanding student scholars are included in a pool of potential future graduate students. Reciprocal study abroad programs are very effective methods to build collaboration among universities and facilitate impactful global learning experiences for the individual student participants.

**Weed Control and Pest Management 1 (Poster)**

**Influence of Physical Properties of Common Landscape Mulch on Emergence of Two Weed Species** *(Poster Board #168)*

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Dennis C. Odero
University of Florida, Belle Glade, FL, USA

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University of Florida, Gainesville, FL, USA

Mulch can reduce weed growth but it not clear how physical properties of mulch affect weed emergence. To determine how different mulch materials and physical properties affect weed emergence, outdoor and greenhouse experiments were conducted in Apopka, FL. For the greenhouse experiment, containers (3.8 L) were filled with standard substrate and divided into two halves using plastic sheets. Crabgrass *(Digitaria sanguinalis)* or garden spurge *(Chamaesyce hirta)* seeds were sown to half of each container either above or below pine straw, pine bark or hardwood mulch at depths of 0, 1.3, 2.5, 5.1, or 10.2 cm. For the outdoor experiment, nursery containers (11.4 L) were filled, mulched, and seeded in a similar manner. A square transparent plastic tube was inserted in the center of each container, below the mulch layer and light intensity measurements were recorded using a LICOR® LI-191R sensor. Particle size analysis of mulch materials was conducted separately using soil sieves ranging in size from 1–25 mm. Moisture retention by mulch was also recorded using moisture sensors and by recording water retention in the mulch layer following 2.5 cm of irrigation at 1.4, and 24 h after application using Buchner funnels. Data collection included biweekly weed counts, light measurements under mulch layers, moisture levels in the mulch layer, and drainage through mulch layers. Weed emergence decreased 37 to 90% when seeds were placed below the mulch layer in all mulch types for both weed species compared with seeds placed above mulch. Mulch type had no influence on emergence when weeds were placed below layers of 2.5 cm or greater. When seeds were placed above the mulch layer, pine straw or pine bark had 63 to 83% fewer weeds compared to hardwood. Particle size analysis showed hardwood was composed of smaller particle size and had 60% greater moisture holding capacity compared with other mulch materials. Light sensor data showed mulch depths > 2.5 cm excluded 99.5% of light and there was no difference in light readings at higher mulch depths. Results from these trials suggest that for the species evaluated, weed emergence will likely increase when seeds are present (introduced) above mulch layers compared with seeds already present in the soil. Pine bark and pine straw may provide greater weed control compared with hardwood mulch due to less moisture holding capacity but mulch type will have less influence on emergence of seeds already present in the soil when as depths increase.

**Use of Topramezone Herbicide for Weed Control in Native and Ornamental Grass Plantings in Florida** *(Poster Board #169)*

Chris Marble*
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Annette Chandler
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Ornamental grasses are popular in golf course natural areas and in landscapes due to their pest resistance and ability to thrive in low-input environments. While many grass species are naturally disease and or insect pest resistant, weed control continues to be a challenge for both landscape pest control operators and golf course superintendents managing large monocultures of native/or ornamental grasses. Research was conducted in 2016 and 2017 in Apopka, FL, to determine the response of 14 different ornamental grasses to over-the-top applications of toprazone, a new HPPD inhibiting herbicide. Uniform and fully-rooted liners were planted in the field and allowed 2 months to establish prior to treatment. At this time, toprazone was applied over-the-top to each species at rates of 0.05 and 0.10 kg·ha⁻¹ active ingredient (a.i.) using a CO₂ backpack sprayer. A sequential application followed 6 weeks later using the same rates. Species evaluated in 2016 included *Schizachyrium scoparium* ‘The Blues’ (little bluestem), *Tripsacum dactyloides* (eastern gamagrass), *T. floridanum* (florida gamagrass), *Chasmanthium latifolium* (wild oats), *Muhlenbergia capillaris* ‘White Cloud’ (white cloud muhly grass), *Eragrostis elliotii* ‘Wind Dancer’ (wind dancer lovegrass), *Panicum virgatum* (Red switchgrass), and *Spartina bakeri* (sand cordgrass). *Andropogon virginicus* (broomsedge), *Miscanthus sinensis* ‘Purpurescens’ (purple miscanthus), little bluestem, *Sorghastrum nutans* (indian grass), *Carex appalachica*
Many pinebark suppliers now organize inventories based on particle size (e.g. 2 or 1 cm, etc.) to create custom blends for growers. Experiments were conducted in 2016 and 2017 to determine the influence of pinebark particle size on weed growth and preemergence herbicide efficacy when subjected to similar irrigation regimes. Pinebark was obtained from a local supplier in Apopka, FL, and separated into three particle sizes including 6.3 (large), 2.8 (medium), and 1.4 mm (fine) using soil sieves. Standard amendments (fertilizer, lime, micronutrients) were incorporated in each substrate. Substrates were then treated with two rates of prodiamine [0.84 and 1.7 kg·ha⁻¹ active ingredient (a.i.)], dimethenamid-P (0.84 and 1.7 kg·ha⁻¹ a.i.) or indaziflam (0.04 and 0.08 kg·ha⁻¹ a.i.) using a CO₂ sprayer at 468 L·ha⁻¹ application volume. Seeds of Eclipta prostrata (eclipta), Digitaria sanguinalis (crabgrass), Oxalis stricta (oxalis), and Pilea microphylla (artillery weed) where then surface sown onto pots.

Eclipta were sown to pots treated with indaziflam, oxalis were sown onto pots treated with dimethenamid-P, and artilleryweed and crabgrass were sown onto two separate groups of pots treated with prodiamine. Pots were kept inside a greenhouse and irrigated 0.8 cm per day. Data collected included weekly weed counts and shoot fresh weights at 8 weeks after seeding. The trial was designed as a 3 × 2 factorial with three particle sizes and two rates of herbicide. In nontreated pots, substrate particle size significant for all four weed species with growth increasing as particle size decreased. Shoot fresh weight increased by 33, 117, 49, and 318% for crabgrass, eclipta, oxalis, and artilleryweed, respectively, when comparing weeds growing in small particle substrates to those growing in large particle substrates. This was likely due to higher water holding capacity of the smaller particle substrates as irrigation was not adjusted for different particle sizes. In herbicide treated pots, particle size did not influence herbicide efficacy for any species. Rate was significant in both eclipta and oxalis, however both rates provided over 90% control, and there were no rate × particle size interactions for any species. Based on these results, normal particle size ranges used in nursery production will likely have little effect on herbicide efficacy if proper herbicides and rates are applied for problematic species. In outdoor production where total water applied (irrigation and rainfall) is more difficult to manage, weed growth will likely increase in substrates with higher water holding capacities.

**Influence of Pinebark Particle Size on Preemergence Herbicide Efficacy and Growth of Four Container Nursery Weed Species**

(Poster Board #170)

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The use of organic and inorganic mulching helps plants to grow by inhibiting the growth of weeds, retaining soil moisture, and regulating the temperature of soil. The objective of this study was to determine the effects of different organic mulches on weed presence, soil characteristics, and growth of Zinnia elegans. The mulches used in studying *Zinnia elegans* were wheat straw, non-shredded Miscanthus (*M. × giganteus*), and shredded *M. × giganteus* mulch. A randomized complete-block design (RCBD) was used in the study, with different quantitative methods used to collect data, and ANOVA tests were utilized to statistically analyze data. The research found that shredded *Miscanthus × giganteus* was the most useful mulch in reducing weed pressure. The results of the study also showed a statistically significant difference between mulch treatments and the control, on *Zinnia elegans* growth. The use of non-shredded *M. × giganteus* and wheat straw resulted in significant increased macronutrient and micronutrient levels in the soil. Also, non-shredded *M. × giganteus* mulch correlated with increased stem diameter, stem length, flower set, and the formation of flower buds, as compared to wheat straw and shredded *M. × giganteus*.

**The Effect of Three Different Mulches on Weed Presence, Zinnia Growth, and Soil Characteristics**

(Poster Board #171)

Anmar A. Muttaleb*
Murray State University, Murray, KY, USA

The use of organic and inorganic mulching helps plants to grow by inhibiting the growth of weeds, retaining soil moisture, and regulating the temperature of soil. The objective of this study was to determine the effects of different organic mulches on weed presence, soil characteristics, and growth of *Zinnia elegans*. The mulches used in studying *Zinnia elegans* were wheat straw, non-shredded *Miscanthus (M. × giganteus)*, and shredded *M. × giganteus* mulch. A randomized complete-block design (RCBD) was used in the study, with different quantitative methods used to collect data, and ANOVA tests were utilized to statistically analyze data. The research found that shredded *Miscanthus × giganteus* was the most useful mulch in reducing weed pressure. The results of the study also showed a statistically significant difference between mulch treatments and the control, on *Zinnia elegans* growth. The use of non-shredded *M. × giganteus* and wheat straw resulted in significant increased macronutrient and micronutrient levels in the soil. Also, non-shredded *M. × giganteus* mulch correlated with increased stem diameter, stem length, flower set, and the formation of flower buds, as compared to wheat straw and shredded *M. × giganteus*.
Poster Presentations

**Abrasive Weeding Paired with Mulch Film Increases Yield and Profitability of Organic Pepper Production (Poster Board #172)**
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University of Nebraska–Lincoln, Lincoln, NE, USA
Emily Braun
University of Illinois, Urbana, IL, USA
Frank Forcella
USDA-ARS Soils Lab, Morris, MN, USA
Sharon Clay
South Dakota State University, Brookings, SD, USA
Daniel Humburg
South Dakota State University, Brookings, SD, USA

Weeds are a top management concern among organic vegetable farmers. Abrasive weeding is a newly developed non-chemical tactic that uses air-propelled abrasive grits to destroy weed seedlings within crop rows. Many different grit types are effective, but if organic fertilizers are used as abrasive grits it could allow farmers to integrate weed and nutrient management in one field pass. Our objective was to determine if abrasive weeding with organic fertilizer grits can be used in combination with agricultural mulches to increase weed suppression, yield, and profitability in organic vegetable systems. A two-year factorial experiment was conducted in organic red pepper (*Capsicum annuum* ‘Carmen’) at Urbana, IL with four replicates of five abrasive grit treatments (walnut shell grits, soybean meal fertilizer, Suståne composted turkey litter fertilizer, a weedy control, and a weed-free control) and four mulch treatments (straw mulch, bioplastic film, polyethylene plastic film, and a bare soil control). Abrasive weeding alone reduced in-row weed density by 35%, and mulch films alone reduced in-row weed density by 86%. Combining the two tactics reduced weed density by 94 to 98%, regardless of grit type. In-row weed biomass was greater in planting holes of films compared to bare soil, but abrasive weeding reduced that biomass by 77 to 87%. Films alone increased yield 6-fold, whereas films plus abrasive weeding increased yield 8-fold. Abrasive weeding combined with mulch films for weed control increased net income by an average of $29,260/ha, but that profit could be doubled if weed-free conditions are achieved via hand-weeding or two additional grit applications.

**Specified Source(s) of Funding:** USDA NIFA OREI award # 2014-51300-22233

**Utilizing Industrial Hemp As a Cash or Cover Crop to Address Weed Pest Issues and Enhance Soil Health in Organic Agriculture (Poster Board #173)**
Tara A. Caton*
Rodale Institute, Kutztown, PA, USA

Industrial hemp, a versatile plant grown for its fiber, seed or oil, was a valuable cash crop and a major industry in Pennsylvania for more than 260 years prior to its ban in 1933. Due to its close relationship to the marijuana plant, hemp production became a casualty of a 1933 law banning marijuana, and was later named a Schedule 1 drug by the Controlled Substances Act of 1970. In 2017, Rodale Institute was one of 16 organizations that received a permit for the inaugural planting of hemp in Pennsylvania in more than 80 years as part of the Pennsylvania Department of Agriculture Industrial Hemp Pilot Program. A four-year research project was initiated to evaluate industrial hemp varieties that are most suited to soil and climatic conditions in Pennsylvania. Organic farmers are interested in growing hemp but require research-based information that will help them make informed decisions about integrating hemp into their rotations. The project has two components; 1) a variety trial that aims to determine available varieties with greatest seed yield and fiber content, and 2) a weed suppression trial that aims to establish hemp as a dual cover and cash crop. Three varieties are being assessed for weed suppression, viability, height, hemp biomass, seed yield, and effect on soil physical and chemical properties. The weed competition trial is evaluating potential of hemp to act as a substitute cover crop in common organic tilled and no-till crop rotations, as a weed suppression cover crop. Preliminary results indicate that both ‘Santhica’ hemp variety and sorghum Sudan grass equally suppress weeds compared to control. The data indicate that hemp suppresses ragweed better than Sudan grass, while the latter suppresses lambsquarters better than hemp. Data also suggest that ‘Santhica’ hemp and Sudan grass reduce soil bulk density. After nearly 80 years, there are encouraging signs that industrial hemp may soon be legal to grow again in the United States. However, the knowledge needed to grow hemp has largely been lost. Our research will help growers make informed decisions and avoid costly mistakes when hemp is legalized.

**Specified Source(s) of Funding:** Dr. Bronner’s; Nutiva

**Ecological Physiology (Poster)**

**Infrared Thermography Applications in Stress Response (Poster Board #260)**
Amanda Lewis*
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Luis Cisneros-Zevallos
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Greta Schuster
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Infrared thermography is a measurement of an objects emittance of long wave radiation that allows us to visualize the temperature of an object. Stomatal conductance is a parameter frequently measured in plant science research; primarily to determine the effects of stressors on stomata and plant water relations. This gives us insight into plant photosynthesis, water, and stress.

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An asterisk (*) following a name indicates the presenting author.

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status of plants. Porometry is a common measure of stomatal conductance, which requires contact with the leaf surface, and can influence the measurement being taken. Thermal imaging offers advantages over porometry for measurement of stomatal conductance. The objective of this study is to explore applications of thermal imaging during plant development. Aspects of this study include defining the relationship between thermal image parameters and stomatal conductance in *Capsicum annum* under ambient and drought stressed conditions. It is expected that the relationship between stomatal conductance and thermal index, calculated using thermal imaging data, will be linear and proportional. Preliminary research conducted on three tomato cultivars found a linear relationship between thermal index and stomatal conductance in all cultivars, and proportionality in one cultivar. It was also found that thermal index could be used to identify phenotypic differences in response to light stimulus in the tomato cultivars tested. Ongoing research to establish the relationship between stomatal conductance and thermal index will allow us to use thermal imaging to quantify and visualize dynamic stomatal response to drought stress in *C. annum*. This will be confirmed by analysis of stress response compounds in plant tissue samples.

**Specific Source(s) of Funding:** USDA/NIFA NNF Award No. 2014-38420-21798

**Title:** Sustainable Agriculture in Semiarid Areas: An International & Interdisciplinary Approach to Graduate Education

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**Impact of High Root Temperature on Heat Tolerant and Intolerant Lycopersicon esculentum Variety Photosynthetic Rate**

*(Poster Board #261)*

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In many cases, testing tomato cultivars for temperature tolerance involves subjecting the entire plant (including roots) to high or low temperatures and fails to distinguish the impact of root system stress in overall plant photosynthetic responses. We previously determined root respiration rates of eight tomato cultivars varying in heat tolerance that also vary in root respiration responses to root zone temperatures ranging from 44.1 to 59.1 °C (+/- 0.4 °C). In this study, root temperatures of heat tolerant and heat intolerant tomato varieties were maintained at 25 °C and 55 °C (previously determined as a non-stressful and stressful temperature, respectively) while aboveground stem and leaf tissues were maintained at 26 °C (previously identified as optimal for photosynthesis in tomato) to determine whether photosynthetic activity of heat tolerant and intolerant tomato varieties was impacted by high root temperatures differently. Specifically, we sought to determine the degree to which aboveground photosynthetic activity is associated with root sensitivity to high temperature.

**Specific Source(s) of Funding:** USDA-ARS; FRA; Minnesota Agriculture Experiment Station

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**Effect of Incremental Temperature Increase on Blueberry Pollen Production and Viability**

*(Poster Board #262)*

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Nicole L. Waterland

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Blueberry is a popular and economically important crop that is primarily pollinated by bees. Crops that require bee pollination must produce a sufficient amount of viable pollen, since bees pack pollen onto their scopae most of the pollen collected is unavailable for pollination. Changes in climate have yielded warmer temperatures impacting flower development including pollen production and the activity of pollinators. Many studies have investigated the viability of pollen exposed to elevated temperatures for short time periods. In other studies pollen was collected under ideal temperatures and then placed under temperature treatments. The objective of this study was to determine the impact of long term exposure to incrementally increasing temperature on the production, release, and viability of pollen from two cultivars of highbush blueberry (*Vaccinium corymbosum* L.) ‘Blueray’ and ‘Jersey’. Plants were grown at five temperatures 18, 20, 24, 28, and 31 °C under natural irradiance in a greenhouse. Pollen release was evaluated by rolling the flower. Pollen viability was determined by plating pollen on germination media, plated pollen was stored for two hours at the same temperature treatment. Pollen viability, mean number of pollen tubes per germinated tetrad and pollen tube length were evaluated. The longest pollen tube length was observed from plants grown at 18 °C. Few flowers were produced, however, at 31 °C and most of the pollen collected failed to germinate. Our data suggested that long term exposure to even relatively small increases in temperature negatively affected pollen viability. Temperature increase due to climate change could decrease not only activity of pollinators, but also pollen production and viability raising a great concern since it has been liked to poor fruit set, potentially decreasing fruit yield.

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**Shade Avoidance: Can We Breed for Weed Resistance?**

*(Poster Board #263)*

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The ability of plants to respond to disease causing pathogens by acquiring systemic resistance when exposed to those pathogens has been widely studied. Previous research with Arabidopsis has established that such acquired defenses can be even more pronounced in the progeny than the parental plant population, analogous to vaccinating a parent and seeing immunity in their children. The ability of weeds to similarly induce weed resistant crops has not yet been established. Plants can sense when other plants are close, a response referred to as shade avoidance, attributed to their response to red:far-red ratio of the light spectrum. Given that plants absorb the red-light spectrum for photosynthesis, far-red light spectrum is normally reflected.
Consequently, there would be a lower red:far-red ratio in densely spaced plants such as a weedy environment compared to a non-weedy environment. This study aims to determine if these responses are heritable and can make the progeny more tolerant to weeds, without compromising their productivity. Greenhouse studies were started in 2015 at Rodale Institute and the University of Wyoming to determine if resistance to weed pressure is a heritable trait induced through competition in the F1 generation. The experiment was designed as a one by three factorial completely randomized block design replicated three times. Oat or wheat plants were planted in cone-tainers surrounded by annual ryegrass, redroot pigweed or soil (control). Test plant measurements of plant height, leaf length and width, and seed counts were taken on a weekly basis. At Rodale, F1 generation seed were saved and planted in the same environment as F1 generation. In Wyoming, saved F1 seed were factorially inter-planted in such a way that they had all possible combinations of weed/soil environments. Preliminary results from Rodale indicated that F2 oat plants exposed to ryegrass tended to be taller than controls. Preliminary results from Wyoming revealed that F2 progeny exposed to weeds or soil, whose parents were exposed to weeds, had 63% and 75% heading respectively while F2 progeny whose parents were not exposed to weeds had only 0% and 13% heading respectively. These results suggest that heading date in second generation wheat was influenced by previous generation’s growing environment than current growing environment—implying that shade avoidance response to weed exposure is heritable.

Specified Source(s) of Funding: Toward Sustainability Foundation

Herbs, Spices, and Medicinal Plants (Poster)

Wild-simulated Production Guide for Ginseng Farmers in Tennessee (Poster Board #386)
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Asian ginseng (Panax ginseng) is a fleshy root plant that has been used for millennia in Asian medicines. American ginseng (Panax quinquefolius) is the North American cousin to the Asian species and both are members of the ivy family. Both the Asian and American species have been valued throughout history, and collected or cultivated for use. The demand for ginseng is highest in the Eastern markets. To meet this demand, both farmers and wild ginseng harvesters have increased output to leverage a growing far-eastern economy. Agricultural scientists have been researching methods to aid farmers in their production of American ginseng. The goals of this paper are 1) to summarize the research of several specialists into one coherent narrative; and 2) to give agricultural producers in Tennessee a working understanding of several variables that affect the growth and value of North American ginseng. By focusing on the wild simulated method, information from a diverse set of disciplines can be delivered to the public in a fashion that allows for its practical use. Also, switching production of ginseng for human consumption from harvesting dwindling wild sources to wild simulated methods can lessen harvest pressure on threatened populations.

Specified Source(s) of Funding: Greenway herbal producers LLC, Middle Tennessee State University

Effects of Environment, Bine Age, and Cultivar on Chemical Quality Metrics of Hops Grown throughout New Jersey (Poster Board #387)
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Hops are considered a key essential ingredient in brewing beers. They are added to beer to impart bittering flavors and aroma compounds, and are known to vary in their chemical composition of each component. Major production areas of the United States are in the Pacific northwestern areas of Washington, Oregon and Idaho. Growers and processors of hops in this region have set quality standards, which growers in newer regions (i.e. the northeastern United States) must meet to ensure brewers will purchase their crop. The purpose of this study was to determine the variation in hop quality characteristics due to age of planting, growing location in New Jersey (NJ), and cultivar. Quality was measured by results of alpha and beta acids and aromatic compound testing. Over 50 samples of hops were collected from 10 farms throughout NJ over a 3-year period, representing over 10 cultivars. Alpha and beta acids were analyzed using the ASBC published (International) method (Hops-14), and compounds were separated and identified by HPLC-UV. Aromatic profiles were determined according to the ASBC method (Hops-17), and the total volatiles were separated and quantified using a Shimadzu TQ8040 gas chromatograph MS. Interestingly, a number of cultivars (i.e. Nugget) showed differences in quality when grown at different locations throughout NJ. In addition, data indicated that several cultivars included in the study showed improvement in chemical composition as a planting aged. Two noteworthy cultivars, Cascade (alpha acid = 5.6% and beta acid = 6.3%) and Ultra (alpha acid = 9.5% and beta acid = 3.9%)

An asterisk (*) following a name indicates the presenting author.
reach optimum quality levels by 2017 (3 years after planting at that site). This preliminary data indicates that NJ-grown hops have the potential to meet hop quality industry standards, but growing location, and age of planting have an effect on the quality of NJ-grown hops.

Specified Source(s) of Funding: Northeast Sustainable Agriculture Research and Education

Evaluation of Ginger Cultivars in a Greenhouse (Poster Board #388)
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This study evaluated three ginger cultivars—Chinese White (CW), Hawaii Yellow (HY), and Kali Ma (KM)—on their growth and rhizome yields in a greenhouse on the farm of North Carolina A&T State University. Seed gingers were pre-sprouted using coconut coir as the initial substrate. The pre-sprouted seedlings were then potted in 10-L pots filled with pre-mixed substrate containing Metro Mix 360 and compost at 1:1 ratio. Potted plants of all three cultivars were then randomly placed on top of a bench in the greenhouse with drip irrigation. A completely randomized design was used. One tablespoon of fertilizer (Weaver 17–17–17) was added to each pot one month after potting. During the ginger growth period additional substrate was added as needed for hilling purpose. All three cultivars demonstrated vigorous and healthy growth. Among the three cultivars tested, only HY plants had strong aroma and attracted caterpillars that was also observed from our study in a high tunnel. Our data indicated that the three cultivars had very similar growth in terms of stem diameter and plant height, but with significantly different productivity in terms of yield (rhizome weight). Stem diameter data indicated that both CW and KM plants had a little thicker stems than HY plants. Rhizome weight data indicated that CW (625 g/plant) produced slightly higher yield than KM (613 g/plant), and both CW and KM produced significantly higher yield than HY (417 g/plant). According to our observation, the 10-liter size pot is too small for adequate ginger growth.

Exploring Industrial Hemp Production in Western North Carolina (Poster Board #389)
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The first year that industrial hemp could legally be grown in North Carolina was 2017. North Carolina State University researchers conducted field studies across the state on production of industrial hemp for grain, fiber, and floral parts production. We were responsible for the fiber and grain studies in western North Carolina. Fifteen varieties of grain, fiber, and dual purpose varieties were planted in a variety × planting method study at the Mountain Research Station in Waynesville, NC. The study was a split plot design with varieties as the main plots and the planting methods, broadcast and drilled, as the subplots. There were three replications. The well prepared field was fertilized as recommended for corn with 100 lb/acre of nitrogen (N) and overhead irrigation was applied as needed. A similar study was established at a research station in Mills River but was lost to torrential rains shortly after sowing. Due to delays in obtaining seed, the field studies were planted much later than planned. This was a big concern since industrial hemp is photoperiod sensitive and many of the varieties were from Canada, where the spring day lengths are substantially longer than in our growing region. Our study was planted on 19 June. Germination was fast, high, and uniform in the drilled plots and the plants quickly established themselves and effectively out competed most weeds. The broadcast plots were much more irregular in germination and weeds, particularly pigweed, grew right along with the hemp seedlings. Many diseases and insects were found and identified in the plots but none caused any noticeable problems. There were big differences in plant height, flowering dates, and weed presence among the varieties, but in general, all varieties grew well. Stalks were harvested from three varieties and provided fresh weight yields of 10–13 t/ha. Grain was harvested from the remaining 12 varieties with a combine and averaged between 0.9–1.5 dried kg/ha.

Specified Source(s) of Funding: North Carolina Agricultural Foundation

Productivity and Quality Traits of Citron Essential Oil from Jindo
(Poster Board #390)
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Citron from Jindo is a tree grafted with trifoliate orange grafted fruit that has good environmental adaptability against low or high temperatures. Due to its hard pulp and sour taste, it is more beneficial to use as a fragrance source than an edible resource.
In this study, citron was harvested by each harvest time in October, November and December, and researched productivity and quality of oil to use citron produced in Jindo as a fragrance resource. The crops of citron by the harvest time were 3288kg in October, 3587 kg in November, and 4200 kg in December per 10 a: indicating that the later the harvest time, the more the crop. When oil productivity of citron was researched based on 1 kg of the citron peel extracted through steam distillation, the October yield was 24 (mL/kg), the November yield was 22.2 (mL/kg) and the December yield was 18.0 (mL/kg). With regard to the intensity of fragrance of natural oil, the crop harvest in October had strongest fragrance with 3203 (A.U./1 g) and the intensity fragrance decreased as the later harvest times. It shows that the best time for harvesting citron for oil production is October.

### In Search of “Nutri-chemicals” in Yellow Capsicum Spp. Fruits (Poster Board #391)

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There are over 700 different carotenoids in nature. Carotenoids are the yellow, red, and orange pigments. They are found in plant chloroplasts and are used to protect plants from taking in too much light which can create reactive oxygen species. We see these pigments every day in our fruits and vegetables such as carrots, which contain high amounts of beta-carotene, an orange pigment. Xanthophylls are the yellow carotenoids. They make up one of the two major carotenoid groups. One specific xanthophyll, lutein, has been proven to aid improvement of cognitive health and decrease risks of age-related macular degeneration. The cognitive function that lutein helps with is memory loss. Macular degeneration is vision loss due to the wear and tear that happens to our eyes over time and after long exposure times to blue light. Lutein has been shown to be part of the macular pigment that sits on the nerves of the retina and help absorb the blue light that we are subjected to daily. Macular degeneration and memory loss risks increase with age, but what if it was possible to slow this process down? Chile peppers, Capsicum species fruits are one of the few fruits and vegetables that accumulate xanthophylls such as lutein. For this reason, forty-eight genetically diverse yellow chile peppers from New Mexico State University’s Chile Pepper Institute Teaching Garden and Leyendecker Plant Science Research Center were harvested for lutein and beta-carotene analysis. These peppers were cut up, frozen in liquid nitrogen, ground up and extracted. All carotenoids were extracted from the peppers. After extraction, peppers were filtered and qualitative analysis was done using thin-layer chromatography (TLC). Afterward, high performance liquid chromatography (HPLC) along with carotenoid standards were used to quantify exact amounts of beta-carotene and lutein. These results found that five of the forty-eight yellow peppers were found to have high amounts of only lutein, while the other 43 peppers contained a mixture of carotenoids. This research profiled chile carotenoids, including lutein which has been shown to combat macular degeneration and aid in cognitive brain function. Future research will quantify the amount of lutein that is bioavailable to the body.

**Specified Source(s) of Funding:** USDA NIFA Broadening Agricultural Science for Hispanics

### Phenolic and Capsaicinoid Concentrations and Antioxidant Capacities in Chili Peppers Grown in the Delmarva Peninsula As Affected by Cultivars and Maturity (Poster Board #392)

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Chili peppers are fruits of genus Capsicum plants of which are grown worldwide. They are goods sources of bioactive phytochemicals, such as phenolic compounds and capsaicinoids, whose health protective effects are well-known. Capsaicinoids are the major bioactive phytochemicals in chili peppers, responsible for their hotness. Concentrations of bioactive phytochemicals in plants depend on genetic (cultivar and maturity) and environmental (climate) factors. In addition, their concentrations differ among parts of the fruit. This study compared phenolic and capsaicinoid concentrations and antioxidant capacities in different cultivars of chili peppers at different maturity stage. They were also compared in different parts (seed, placenta, and flesh) of the chili peppers. These cultivars were grown in the temperate climate of the U.S. Delmarva Peninsula. Six chili pepper cultivars (Scotch Bonnet (SB), Habanero Red and Orange (HR and HO, respectively), Hot Lantern (HL), Numex Suave (NS), Bangko F1 (BF), and Sahuarro (S)) were grown in the field in the University of Maryland Eastern Shore Experiment Station in 2015. They were harvested at green and ripe mature stages. Immediately after harvest, seeds, placenta, and flesh were separated. Subsequently, the whole pepper and separated parts were freeze-dried, and stored at −18 °C freezer until analysis. Concentrations of phenolic compounds (as total phenolic and flavonoid contents) and capsaicinoids and antioxidant capacities (as 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging capacity and oxygen radical absorbance capacity) were determined using 80% ethanol extracts from the dried samples. Data

An asterisk (*) following a name indicates the presenting author.
were analyzed using analysis of variance and means were compared using the Student-Newman-Keuls multiple comparison method \((P < 0.05)\). At the green maturity stage, the phenolic concentrations and antioxidant capacities were likely higher in HO, SB, and BF than in HL, NS, and S, and the concentrations of total capsaicinoids (capsaicin + dihydroxycapsaicin) varied among the cultivars as follows: HO = SB > HR > HL = BF > S = NS \((P < 0.05)\). As they became matured, the phenolic concentrations and antioxidant capacities in HL significantly increased \((P < 0.05)\) and those in BF significantly decreased \((P < 0.05)\). In addition, the capsaicinoid concentrations in HR and BF significantly decreased \((P < 0.05)\). No change was observed in other cultivars during maturation. Consequently, at the ripe maturity, the phenolic concentrations and antioxidant capacities were greatly higher in HO and SB than in NS and S, and the concentrations of total capsaicinoids varied among the cultivars as follows: HO = SB > HR > HL = BF > S = NS \((P < 0.05)\). The results indicated that HO and SB grown in the Delmarva Peninsula could be good sources of bioactive phenolic compounds and capsaicinoids at any maturity stage.

**Comprehensive Transcriptome Analysis of *Ligularia fischeri* to Identify Isoforms and Biosynthesis Genes Associated with Medicinal Components** *(Poster Board #393)*

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* *Ligularia fischeri* is a popular edible herb in Korea containing broad ranges of pharmacologically important compounds. It is used in traditional medicine for treating infectious and inflammatory diseases. Despite its importance as herbal medicine, there are no transcriptome/genome sequences available in the public database limiting its research at molecular level. To address this issue, a transcriptome analysis of *L. fischeri* was performed using Pacific Biosciences single molecule long-read isoform sequencing platform. We identified 60,646 polished, high-quality non-redundant full-length transcripts with a total length of 116.5Mb. Among these 27,453 transcripts were annotated to known genes in different species based on non-redundant and uniprot database. Functional classification using Gene ontology identified 11,279 transcripts of which majority were associated with the cellular and metabolic process. The Kyoto Encyclopedia of Genes & Genomes pathway analysis identified 1332 transcripts encoding 160 enzymes related to secondary metabolism with a higher number of transcripts for biosynthesis of antibiotics. Furthermore, we observed alternate splicing, in a total of 1,030 transcripts covering a total of 2250 isoforms with a variable of 2–11 isoforms. This data led us to identify 117 transcripts containing 271 isoforms involved in various metabolic pathways along with 36 transcripts containing 84 isoforms involved in various stress responses. This is the first detailed transcriptome analysis of *L. fischeri*. The resulting transcriptome along with the identified alternative splicing events provides insights into the biological process including the genes related to biosynthesis of characteristic secondary metabolites. This data will be valuable resource as transcriptome reference for further studies in the genetics and breeding of *L. fischeri*. *Specified Source(s) of Funding:* RDA(Rural Development Administration)

**Optimizing Extracting Conditions of Citrus Junos Oleoresin Rich in Naringin and Hesperidin Contents** *(Poster Board #394)*

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* *Junos* oleoresin is a popular herbal medicine in Korea containing naringin and hesperidin. There are no reports about the extracting conditions of *Junos* oleoresin. However, *Junos* oleoresins used in traditional medicine for treating infectious and inflammatory diseases. Despite its importance as herbal medicine, there are no transcriptome/genome sequences available in the public database limiting its research at molecular level. To address this issue, a transcriptome analysis of *Junos* oleoresin was performed using Pacific Biosciences single molecule long-read isoform sequencing platform. We identified 60,646 polished, high-quality non-redundant full-length transcripts with a total length of 116.5Mb. Among these 27,453 transcripts were annotated to known genes in different species based on non-redundant and uniprot database. Functional classification using Gene ontology identified 11,279 transcripts of which majority were associated with the cellular and metabolic process. The Kyoto Encyclopedia of Genes & Genomes pathway analysis identified 1332 transcripts encoding 160 enzymes related to secondary metabolism with a higher number of transcripts for biosynthesis of antibiotics. Furthermore, we observed alternate splicing, in a total of 1,030 transcripts covering a total of 2250 isoforms with a variable of 2–11 isoforms. This data led us to identify 117 transcripts containing 271 isoforms involved in various metabolic pathways along with 36 transcripts containing 84 isoforms involved in various stress responses. This is the first detailed transcriptome analysis of *L. fischeri*. The resulting transcriptome along with the identified alternative splicing events provides insights into the biological process including the genes related to biosynthesis of characteristic secondary metabolites. This data will be valuable resource as transcriptome reference for further studies in the genetics and breeding of *L. fischeri*.
Citrus junos is a universally consumed fruit in Eastern Asian countries such as Korea, China, and Japan and the fruit is originally from those countries. In Korea, Jeollanamdo, one of provinces, about 81.6% of citrus junos fruits are produced per year. The fruit has very strong sour taste, so it makes hard for consumers to eat raw. Thus, consumers generally make the fruit tea with sweeteners. Citrus junos is known to contain significant amount of antioxidants including vitamins and phenolic compounds but only limited information is available how well those antioxidants are extracted when it is consumed as tea and what the best extraction condition is. The objectives of this study were to determine optimize extraction conditions and to quantified active compounds as flavonoids content (naringin and hesperidin) in extracted citrus junos oleoresin for application of food and cosmetic ingredients in the future. Citrus junos skins were mixed with several different ratios (Wt/Vol %) ethanol (>95%) for determination of yield for extraction. The best extract yield was 1:10 ratio (Wt/Vol %). For factors of temperature and time for extraction, the best conditions of temperature and time were at 40 °C and 5 hours which yield was 10.8% for extraction of oleoresin. Also other results of activity compounds of the fruit were as: 88.2 Vitamin C eq. mg/100g for antioxidant activity, 518.2 mg/100 g for total flavonoids [hesperidin (107.3 mg/10 g), narirutine (80.8 mg/100 g), neohesperidin (58.5 mg/100 g), and naringin (58.1 mg/100 g)]. Utilizing the results of this study, Citrus junos is higher application areas for food ingredients for producing functional drinks and snacks and cosmetics ingredients due to high content of flavonoids of the fruit.

Nursery Crops (Poster)

Relative Salt Tolerance of 11 Varieties of Hydrangea (Poster Board #130)

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A greenhouse study was conducted to assess the relative salt tolerance of 11 varieties of hydrangea: Hydrangea macrophylla ‘Ayesha’, ‘Emotion’, ‘Mathilda Gutges’, ‘Merritt’s Supreme’, and ‘Passion’, H. paniculata ‘Pink Diamond’ and ‘Quickfire’, H. quercifolia ‘Snowflake’, H. serrata ‘Preciosa’, H. serrata x macrophylla ‘Sabrina’ and ‘Selina’. Softwood cuttings received from a commercial company were rooted in a mist propagation bench. Seven weeks after propagation, rooted cuttings were transplanted to one-gallon containers filled with Metro-mix 360. Six weeks after transplanting, uniform plants were selected for experiment. Plants were irrigated with a nutrient solution at an electrical conductivity (EC) of 1.2 dS·m⁻¹ (control), or nutrient-solution based saline solutions at EC of 5.0 dS·m⁻¹ (EC 5) or 10 dS·m⁻¹ (EC 10) for eight weeks. Four weeks after treatment, ‘Quickfire’ plants in EC 10 exhibited severe salt damage with most of them dead. ‘Pink Diamond’ is the next sensitive cultivar showing salt damage in EC 10, while ‘Passion’ also showed some damage with lower yellow leaves. By the end of the eight week experiment, most ‘Quickfire’ were dead in both EC 5 and EC 10, while ‘Pink Diamond’, ‘Preciosa’, and ‘Passion’ had severe salt damage in EC 10. ‘Ayesha’ and ‘Sabrina’ did not have obvious visual salt damage. ‘Merritt’s Supreme’ and ‘Mathilda’ plants in EC 5 had minimum salt damage. Total shoot dry weight of all cultivars were significantly reduced compared to the control in the elevated salinity, except for ‘Selina’. A second experiment was conducted two weeks later than the first one using the same plant materials, that is, plants were two weeks old at the start of treatment compared to those in the first experiment. Both experiments indicated that ‘Ayesha’ and ‘Sabrina’ were relatively salt tolerant, ‘Selina’, ‘Merritt’s Supreme’ and ‘Mathilda’ were moderately tolerant, ‘Emotion’ and ‘Snowflake’ were moderately sensitive, while ‘Quickfire’ was the most sensitive followed by ‘Pink Diamond’, ‘Preciosa’, and ‘Passion’.

Specified Source(s) of Funding: Floriculture and nursery research initiative

Evaluation of a Web-based Irrigation Control System for Container Nursery Plant Production (Poster Board #131)

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A web-based irrigation control system (CIRRIG, Container IRRIGATION) developed at the University of Florida was evaluated in two production nurseries. CIRRIG inputs were onsite weather data, recent leaching fraction (LF) percentage, and sprinkler irrigation duration when LF was determined. CIRRIG used these inputs to calculate daily sprinkler duration needed to satisfy water demand for plants grown with pine bark and Florida peat substrates in 8- to 11-L containers. A programmable logic controller was used to control solenoid valves based on irrigation duration outputs from CIRRIG. An adjacent irrigation zone with the same plants was irrigated based on standard nursery practices. Six irrigation zone pairs of Ilex cornuta...
‘Burfordii Nana’, *Juniperus davurica* ‘Parsonii’, *Loropetalum chinensis* ‘Plum’, *Rhaphiolepis indica*, and *Viburnum odoratissimum* were evaluated during 2016 and 2017. There were two zone pair evaluations for *Ilex*. The production time for each zone pair ranged from three to nine months depending on plant growth rate, plant size when evaluation started, and plant size when marketed. Plant heights and widths were measured when plants were of marketable size and total irrigation water applied was metered. The growth indices (height plus average width) were similar for all pairs except for *Rhaphiolepis*, which had a growth index of 28.8 ± 0.6 for the CIRRIG zone compared to 23.3 ± 0.4 for plants irrigated based on standard practices used at the nursery. CIRRIG resulted in 1% to 13% decrease in water applied for *Ilex*, *Loropetalum*, *Rhaphiolepis*, and *Viburnum*, and 8% and 35% increased in water applied for *Juniperus* and *Ilex* (second evaluation), respectively. These results indicate that similar plant growth was achieved with CIRRIG that automatically adjusted daily amounts of irrigation water applied compared to plants irrigated with traditional practices used at the nurseries. Irrigation water applied in four of the six zone pairs was less or similar when CIRRIG was used compared to the nurseries’ irrigation practices. However, it is important to consider other benefits of CIRRIG such as; electronic history of daily irrigation applications, the ability to control and monitor irrigation offsite via the internet, and time saved with automatic adjustment of irrigation duration.

**Specific Source(s) of Funding:** Southwest Florida Water Management District, Cherrylake

## Pine Bark Substrate “Contaminants:” Determining Sand and White Wood Percentages
*(Poster Board #133)*

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Aged pine bark is one of the most common organic substrate components in the United States, with bark from loblolly or longleaf pines being the most prominent in the Southeastern U.S. Aging is a process in which the bark is piled on the ground and allowed to age for a period of time, usually six months to one year. Aging time can vary between suppliers, or even for the same supplier, based on factors such as space shortages, product demand, or preference. A long-term study was implemented to quantify the changes in the physical properties of longleaf pine bark over the course of twelve months of aging and how sand and white wood contaminants influence those properties. In this study the amount of white wood decreased from 6.3% at month 0 to 3.8% (by volume) at month 12 as a result of decomposition. Bark supplies/suppliers may have higher percent white wood present but that does not suggest the bark quality is bad. White wood is not detrimental...
to crop growth like once believed so this should have no negative effect on the quality of the bark substrate. The amount of sand that accumulated in the bark as a result of being piled on the ground and turned every month with a front-end loader was also calculated. At the beginning of the study (month 0) the sand content was 0.43% by volume and 2.8% by weight of the pine bark. At month 6 the sand content was 0.02% by volume and 14.05% by weight. At month 12 the sand content was 3.19% by volume and 20.15% by weight. The high sand content found in this study was a result of the sandy soil of the testing location. All bark supplies/suppliers may not have the same sand accumulations. This sand percent (and weight) can be significant in shipping weights and should be monitored/considered.

**Hydrological Changes in Pine Bark Substrates during the Handling and Aging Process**

*(Poster Board #134)*

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Aged pine bark is the one of the most common organic substrate components in the United States, with bark from loblolly or longleaf pines being the most prominent in the Southeastern U.S. Aging is a process in which the bark is piled on the ground in windrows and allowed to age for a period of time, usually six months to one year. Aging time can vary between suppliers, or even for the same supplier, based on factors such as space shortages, product demand, or preference. A long-term study was implemented to quantify the changes that occur in temperature profiles in longleaf pine bark windrows over the course of twelve months of aging. Temperature profiles during the aging process are characterized by 1) a rapid initial increase in temperature, 2) a sustained high-temperature period, and 3) a decline to near-ambient temperatures. Pile temperatures were measured on the research site at each month for twelve months. Measurements were taken at three different heights at depths of 1, 2, 3, and 4 ft. using three 4 ft. compost monitoring temperature probes. Temperature data were analyzed as separate readings at each height and depth, as well as averaged across all pile heights and depths to give an average pile temperature per sample date. There was an initial increase in pile temperature from ambient temperatures at project installation, followed by a 4 month long thermophilic phase of the decomposition process. During months 2 through 4, piles maintained average temperatures between 127 to 135 °F, then decreased during months 5 and 6 as microbial activity and ambient temperatures decreased, followed by a gradual increase throughout the remainder of the study, presumably in response to warmer ambient temperatures throughout the spring and summer months. Thermal imaging with a FLIR C2 handheld camera was also investigated as a potential technique to measure pile temperature.

**Cold Stratification Improves Seed Germination of Ptelea trifoliata and Ptelea crenulata**

*(Poster Board #136)*

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North American shrubs in the genus *Ptelea* (Rutaceae) have unfilled potential to increase the diversity of managed land-
scapes and to support populations of pollinators and swallowtail butterflies. White flowers of *Ptelea* are highly fragrant, and pistillate flowers give rise to clusters of distinctive samaras. Vague information on how to optimize germination of seeds of *Ptelea trifoliata*, and no recommendations for *P. crenulata*, prompted us to investigate effects of cold (4 °C) stratification periods of 0, 4, 8, 16 weeks on the germination of seeds of these two species. Samaras were collected from multiple plants of both species in the Midwestern United States (*P. trifoliata*) and California (*P. crenulata*). Eight and 16 weeks of stratification led to 89% and 100% germination, respectively, for *P. crenulata*, and to 73% and 91% germination, respectively, for *P. trifoliata*; shorter periods of stratification resulted in lower germination percentages for both species. Germination value, a measure of speed and uniformity of germination, was higher for seeds of *P. crenulata* stratified for 16 weeks and for seeds of *P. trifoliata* stratified for 8 and 16 weeks than germination value of seeds treated with shorter stratification periods. Peak day, germination distribution, and mean daily germination of the two species did not differ, nor did stratification period affect these measures. All values were calculated based on the number of viable seeds, which was determined with tetrazolium tests on ungerminated seeds. About half of the seeds of both species were not viable. Propagators seeking to grow these two species of *Ptelea* from seed should cold-stratify the seeds for 16 weeks.

**Soil Solarization for Managing Weeds and Soilborne Pathogens in Tree Seedling Nurseries in the Pacific Northwest** (*Poster Board #137*)

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Soil solarization employs solar radiation to heat the soil under a transparent plastic film to achieve temperatures detrimental to certain soilborne pathogens and weed seeds. Most soil solarization studies have been conducted in warm climates, but recent advances in plastic film technology have made it feasible to successfully solarize soil in regions with cooler climates such as the Pacific Northwest. In 2016 and 2017, we conducted pre-plant soil solarization trials for 3–9 weeks during each summer in three tree seedling nurseries in Oregon and Washington. Soil temperature and moisture were measured continuously in solarized and nonsolarized plots at depths of 5 and 15 cm. Mesh packets containing soil from each nursery were buried at the same two soil depths, and after the trial, soil was dilution plated onto selective media for pathogen quantification. Seeds of four weed species (*Poa annua*, *Polygonum pensylvanicum*, *Amaranthus retroflexus*, and *Portulaca oleracea*) were placed in mesh packets and buried at 5 and 10 cm. After the field trials, seeds were tested for germinability; viability was tested with the tetrazolium chloride assay. Fall and spring weed emergence *in situ* was also quantified, and time required for hand weeding was determined. We found significant reductions in soil populations of *Pythium* spp. and *Fusarium oxysporum*. Of the weed seeds tested, solarization was most effective on *Polygonum pensylvanicum*, least effective on *Portulaca oleracea*, and resulted in increased dormancy in *Amaranthus retroflexus*. Results with *Poa annua* differed in the two years. In the year following solarization, the time required to hand weed solarized plots in each of two nurseries was reduced by 55% or 69% relative to nonsolarized plots. In 2017, crop growth was greater in solarized plots than in nonsolarized plots in two of three nurseries; data for the 2018 crop year is not yet available. We developed an online model (<http://uspest.org/soil/solarize>) for growers to estimate the time necessary to solarize soil based on their farm location, start date, and target pest. The model forecasts soil temperatures from solar radiation and air temperature data at local weather stations, and predicts the amount of time necessary to kill target species based on results from controlled environment studies. Soil solarization is a cost-effective, non-chemical approach for managing weeds and certain soilborne pathogens that could potentially be applied to other Pacific Northwest cropping systems such as organic vegetables and berry crops.

*Specified Source(s) of Funding:* Western SARE, Western IPM Center

**Managing Crapemyrtle Bark Scale Infestation in Container Production with Non-neonicotinoid Insecticides** (*Poster Board #138*)

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Crapemyrtle bark scale is a newly introduced insect pest of crape myrtles. Many challenges present when managing this scale in nursery production, including a lack of chemical trials conducted with infested plants. Two container trials were conducted during 2017, each with 60 ‘Natchez White’ crapemyrtles in 1-gal pots.
Pomology 1 (Poster)

A Comparison of Ploidy Level of Claypool Selected American Persimmon Germplasm to Currently Available Commercial Cultivars (Poster Board #416)

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The American persimmon (Diospyros virginiana) is a tree fruit native to the forests of Kentucky. The golden orange fruit are sweet when fully ripened and astringency is reduced. There are two races of persimmon, a tetraploid (60 chromosome) race is centered in the southern Appalachian mountains and adjacent areas, and a hexaploid (90 chromosome) race occupies the range north and west of the tetraploid range. Many current American persimmon varieties have been selected in the wild and are thought to be in the 90 chromosome race. American persimmon improvement began in the late 19th century with the work of James Troop at Purdue University. In 1880, the first named American persimmon cultivar, Early Golden, was selected out of the wild in Illinois. James Claypool continued breeding of American persimmon in the 1970s. Over the course of 20+ years Claypool evaluated over 2000 trees and has made a number of cultivar releases. The objective of this study was to examine the ploidy level of Claypool selected American persimmon germplasm to determine if these varieties contain both the 60 and 90 chromosome races of persimmon as compared to commercially available varieties using flow cytometry. Leaf samples were collected from 18 Claypool selections and 10 commercially available cultivars from the budwood mother blocks at England’s Orchard and Nursery in McKee, KY. Flow cytometer analysis of the leaf samples showed all Claypool selections, including Dollywood, Elmo (A-118), F-34, F-62, H-118 Early Jewel, H-120, H-55a, H-55a, H-63a Claypool, I-115, J-127, J-59 Claypool, K1, K2, K6, Prairie Star, Prairie Sun, as well as the non-Claypool selected cultivars Early Golden, Garretson, Golden Supreme, Meader, Mohler, NC-10, and Yates were all from the 90 chromosome strain. Three non-Claypool selected commercial cultivars were from the 60 chromosome strain: Enis Seedless, Weeping, and Sugar Bear. This data supports that the 90 chromosome strain is also strongly represented in the high quality material of the Claypool germplasm that was selected.

Specified Source(s) of Funding: IR4

Efficacy of Sulfur As a Fungicide to Control Pawpaw Leaf and Fruit Spot (Poster Board #417)

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Pawpaw (Asimina triloba) is a tree fruit native to the Eastern United States and is grown on a small-scale commercially as a niche crop for local markets. A leaf and fruit fungal spot has been observed in pawpaw consisting of a complex of Mycocentrospora asiminae, Rhopalosidium asiminae Ellis and Morg., and Phylllosticta asiminae Ellis and Kellerm. Symptoms include tan spots with dark brown borders on leaves, and dark brown to black superficial spots on the fruit epidermis, followed by cracking of fruit. In some pawpaw varieties, such as ‘Sunflower’ and ‘Susquehanna’, this disease can cause significant loss of yield. Sulfur is known to be the oldest of all pesticides, although sulfur based fungicides are usually applied as a preventive measure and not a cure. The objective of this study was to determine the efficacy of organic certified sulfur based fungicide for the management of leaf and fruit fungal spot in ‘Sunflower’ and ‘Susquehanna’ varieties of pawpaw. The testing of fungicide was conducted on the Kentucky State University Harold R. Benson Research and Demonstration Farm in Franklin County, KY. Sulfur sprays (water control, 0.05 lb/gallon and 0.1 lb/gallon) were applied after fruit set during mid-May. Disease incidence was scored in treatment and control groups of two given varieties. Quantification of disease was done by visually scoring the percentage coverage of lesions on treatment and control fruit. The selection ‘Sunflower’ had a significantly higher incidence of Phylllosticta lesion coverage (20.9%) compared to ‘Susqua-

An asterisk (*) following a name indicates the presenting author.
The pawpaw (Asimina triloba) is a tree fruit indigenous to eastern North America, with small-scale commercial production in the United States and worldwide on the rise. Over 50 pawpaw cultivars are available in the nursery trade, but many older cultivars have small fruit, low yields, and inferior flavor. Seedlings and controlled crosses at the National Clonal Germplasm Repository for Asimina spp. located at Kentucky State University (KSU) have been evaluated for yield, fruit size, and flavor; and several superior selections have been identified for evaluation and potential future cultivar release. To determine the performance of these selections at different locations, pawpaw variety trials including commercially available cultivars (‘Sunflower’ at all sites; KSU-Atwood™ and KSU-Benson™ at the Urbana, OH site) and five advanced selections identified in the KSU Repository Collection (G6-120, G9-109, G9-111, Hi4-1, and H3-120) were established in plantings at three grower cooperator sites, in central Ohio (Urbana, OH; USDA Plant Hardiness Zone 5b), southern Ohio (Aberdeen, OH; USDA PHZ 6a), and southern Kentucky (Bowling Green, KY; USDA PHZ 6b). Tree survival, trunk diameters, and flowering and yield data were collected at all sites. Trees began to fruit in 2015. Hi4-1, Sunflower and KSU-Atwood™ were the most precocious-fruiting selections in the trials. Survival and vigor were greatest in selections Hi4-1, H3-120, and G9-111. Survival was slightly higher at the central Ohio site, likely due to better soil type than the other two sites, both of which had rocky soils. Number of fruit did not significantly vary among cultivars or location, possibly because they are in early production; differences may be seen once the trees reach full mature production. However, there was a trend for Sunflower, G6-120, Hi4-1, and G9-111 to have the most fruit per tree. Fruit weight varied significantly among selections, with the selections H3-120 and Hi4-1 and cultivars KSU-Atwood™ and KSU-Benson™ having the largest fruit, while G6-120 had the smallest fruit; G5-23, G9-109, G9-111 and Sunflower were intermediate in fruit size. Based on data from these trials and an earlier KSU trial, Hi4-1 will likely be named and released in fall 2018, and other selections will continue to be evaluated for potential commercial release.

**Specified Source(s) of Funding:** USDA Evans Allen Research

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**Evaluating Shade Netting and Other Strategies to Overcome Lack of Winter Chill Accumulation in Pistachios (Poster Board #418)**

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Lack of chill accumulation in pistachios has been a growing production issue in the California for the past several years. Growers have been facing crop losses as a consequence of these changes and there is a dire need to address this very important issue. This study hypothesized that some mechanical and chemical methods could be beneficial to compensate for lack of chill or to induce physiological changes in the trees so as to have a normal bloom and crop load. Fifteen-year-old pistachio trees of Kerman variety on UCB-1 rootstock were selected for this study at the California State University Campus in Fresno. The treatments included covering the trees with two type of shade netting (Black and Gray), spray of horticultural oils and kaolin clay dust. These treatments were compared with an unsprayed control over two years. Trees were covered by November 1 and the shade nets removed in late February both years. In the kaolin clay treatments, trees were sprayed with clay material throughout the winter months as and when needed depending on rain events. The idea was to keep the trees covered throughout the chill accumulation period. Temperature and light intensity data were collected both inside and outside the shade netting using dataloggers. Chill accumulation was calculated using dynamic chill accumulation model as described by Glozer (2009). Data on bloom progression, nut growth, nut weight and volume, shell strength progression, yield and number of blanks were collected. The trees under oil spray bloomed significantly earlier than the trees under kaolin clay and shade netting treatments. Oil treatment trees were also ahead of other treatments in progression of nut growth and shell strength until the start of nut fill stage (Stage 3) of nut development. Oil and kaolin treatments resulted in significantly higher number of blanks. The treatments were not statistically different, in different in terms of total yield or split in-shell percentage.

**Specified Source(s) of Funding:** CSU ARI

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**Early Performance of Pawpaw (Asimina triloba) Cultivars and Advanced Selections in Grower Trials at Three Locations (Poster Board #419)**

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The pawpaw (Asimina triloba) is a tree fruit indigenous to eastern North America, with small-scale commercial production in the United States and worldwide on the rise. Over 50 pawpaw cultivars are available in the nursery trade, but many older cultivars have small fruit, low yields, and inferior flavor. Seedlings and controlled crosses at the National Clonal Germplasm Repository for Asimina spp. located at Kentucky State University (KSU) have been evaluated for yield, fruit size, and flavor; and several superior selections have been identified for evaluation and potential future cultivar release. To determine the performance of these selections at different locations, pawpaw variety trials including commercially available cultivars (‘Sunflower’ at all sites; KSU-Atwood™ and KSU-Benson™ at the Urbana, OH site) and five advanced selections identified in the KSU Repository Collection (G6-120, G9-109, G9-111, Hi4-1, and H3-120) were established in plantings at three grower cooperator sites, in central Ohio (Urbana, OH; USDA Plant Hardiness Zone 5b), southern Ohio (Aberdeen, OH; USDA PHZ 6a), and southern Kentucky (Bowling Green, KY; USDA PHZ 6b). Tree survival, trunk diameters, and flowering and yield data were collected at all sites. Trees began to fruit in 2015. Hi4-1, Sunflower and KSU-Atwood™ were the most precocious-fruitting selections in the trials. Survival and vigor were greatest in selections Hi4-1, H3-120, and G9-111. Survival was slightly higher at the central Ohio site, likely due to better soil type than the other two sites, both of which had rocky soils. Number of fruit did not significantly vary among cultivars or location, possibly because they are in early production; differences may be seen once the trees reach full mature production. However, there was a trend for Sunflower, G6-120, Hi4-1, and G9-111 to have the most fruit per tree. Fruit weight varied significantly among selections, with the selections H3-120 and Hi4-1 and cultivars KSU-Atwood™ and KSU-Benson™ having the largest fruit, while G6-120 had the smallest fruit; G5-23, G9-109, G9-111 and Sunflower were intermediate in fruit size. Based on data from these trials and an earlier KSU trial, Hi4-1 will likely be named and released in fall 2018, and other selections will continue to be evaluated for potential commercial release.

**Specified Source(s) of Funding:** USDA Evans Allen Research

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**Investigating the Effect of Warm Temperature Interruption on the Winter Chilling Accumulation of Kiwifruit (Actinidia chinensis Planch. and deliclosa A. Chev.) Using Excised Canes (Poster Board #420)**

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**Specified Source(s) of Funding:** USDA Evans Allen Research

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An asterisk (*) following a name indicates the presenting author.
Golden kiwifruit (*Actinidia chinensis* Planch) has recently emerged as a new potential fruit crop for the Southeastern United States. Successful trials in Alabama, along with initial success at Stephen F. Austin State University, Nacogdoches, TX, has led to more extensive trialing of this crop in Texas. Both *A. chinensis* and *A. delicosa* require winter chilling for overcoming dormancy and for flowering. Texas is subject to both inconsistent chilling and erratic winter temperatures. Warm temperature exposure during winter has resulted in the apparent negation of chilling in other fruit species. This study was conducted to investigate the floral and vegetative response of two pistillate kiwifruit cultivars to warm temperature interruption during chilling accumulation. Dormant one-year-old canes of *A. chinensis* ‘AU Golden Dragon’ and *A. delicosa* ‘AU Fitzgerald’ were collected in Dec. 2018 (335 C.U.), shortly after leaf abscission. Canes were cut to ten nodes after removing the first six basal nodes, placed in jars filled with distilled water, and transferred to respective chilling treatments. Treatments included continuous chilling (in addition to base chilling) at one-week (168 C.U.) increments (0–5 weeks) and chilling exposure at the same increments with intermittent warm temperature. For the warm temperature treatments, each week of chilling was followed by three days of exposure to warm conditions. Chilling and warm temperature exposure were simulated by 7 °C / 4 °C and 25 °C / 17.2 °C (day / night) temperatures, respectively, using separate climate-controlled growth chambers. Following chilling treatments, canes were forced in a third chamber at 22.8 °C to 26.0 °C with LED lighting. Vegetative bud break, along with floral bud number and development stage, were recorded for each cane and with respect to nodal position at two-day intervals. Maximum flower bud number was highly dependent on chilling exposure ($R^2 = 0.99$ for ‘AU Fitzgerald’) for the consistent chilling treatments. A strong node-position influence was also observed, with distal nodes producing more vegetative shoots and floral buds. While warm temperature interruption resulted in an insignificant reduction in average flower bud number (per-cane) for ‘AU Fitzgerald’, a significant increase was observed for the ‘AU Golden Dragon’ at higher chilling treatments. At 4- and 5-week chilling treatments, 634% and 449% more flower buds, respectively, were recorded as compared to treatments with the same amounts of consistent chilling. These results suggest that the two species may respond differently to intermittent warm winter temperatures, and perhaps even favorably in the case of *A. chinensis*.

*Specified Source(s) of Funding:* Evans Allen

**Effect of Foliar Application of Plant Growth Regulators on Yield and Vivipary of Pecan Trees Growing under Dry and Hot Conditions**

*Poster Board #422*

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Pecan growers experience profitability losses due to nut vivipary when orchards are growing under warm and dry conditions. The goal of this study was to evaluate the effect of three plant growth regulators on pecan nut yield and vivipary. Treatments evaluated were: 1) Azoxystrobin (AZ, 150 g·ha$^{-1}$), 2) Trinexapac ethyl (TE, 500 g·ha$^{-1}$), 3) Paclobutrazol (PB, 125 g·ha$^{-1}$), 4) the mixture of treatments 1 and 2, AZ+TE, and 5) the Control, without application. Treatments were sprayed to drip irrigated adult ‘Wichita’ pecan trees (~40 years old) using 1800 L·ha$^{-1}$ of water and an adjuvant was added at a rate of 0.5 mL·L$^{-1}$. Treatments were applied three times, and application dates...
An asterisk (*) following a name indicates the presenting author.

**Phenotype Characterization of Pistachio Bushy Top Syndrome-affected Trees Entering Maturity (Poster Board #423)**

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Pistachio bushy top syndrome (PBTS) has affected pistachio (*Pistacia vera* L.) orchards planted on an interspecies clonal rootstock (‘UCB-1’) between 2011 and 2016 in California, Arizona, and New Mexico. PBTS is caused by concurrent infection by two plant-pathogenic *Rhodococcus* spp., both of which harbor virulence genes typically housed on a linear plasmid. Because of the unprecedented nature of PBTS, no research-based data are available to predict the long-term productivity of PBTS-affected trees in orchards, and affected orchards have largely been removed due to a concern of future economic productivity. The objectives of this work include: i) phenotypic characterization of PTBS symptomatic and asymptomatic trees entering maturity (i.e. yield, frequency of suckering, bark morphology, trunk caliper, total scaffold caliper diameter), ii) assessment of variability within symptomatic and asymptomatic populations for phenotypic characteristic estimates, and iii) determination of endo- and epiphytic populations of PBTS *Rhodococcus* isolates associated with foliage of rootstocks on symptomatic and asymptomatic trees. Phenotypic data on trees entering their eighth leaf indicate that PBTS-symptomatic trees are both smaller and more variable in size than asymptomatic trees, and have over 70% reduction in yield. Symptomatic trees also exhibit greater suckering than asymptomatic trees and unique bark morphology on the rootstock. PBTS-affected trees had significantly more blank nuts and higher variability in edible yield than asymptomatic trees. Epiphytic populations of PBTS *Rhodococcus* spp. were prevalent on both symptomatic and asymptomatic trees, indicating bacterial transmission within the field. Endophytic populations were only detected on symptomatic trees, suggesting that infectivity in the field is limited. The higher phenotypic variability in symptomatic than asymptomatic trees suggests that PBTS-affected trees exhibit varying levels of disease severity. The current study illustrates that PBTS causes reduction in yield and nut value at harvest. The economic cost of PBTS is compounded by the long-term land use opportunity cost and tree maintenance costs associated with pistachio, a crop that typically has its first economic yield seven years after planting.

**Specified Source(s) of Funding:** Fundacion Produce Sonora, AC

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**Effect of Elevated Temperature and Drought Stress on Accumulation of Photosynthate in Jujube ‘Lingwuchangzao’ Assessed by $^{13}$C Isotope Tracer Technique (Poster Board #424)**

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Photosynthetically assimilated carbon (C) is transported from source leaves to stems and fruits depending on their development stage and environmental conditions. Knowledge about the effect of elevated air temperature and drought stress on photosynthetic assimilation and allocation is important for developing best crop management practices. To examine the translocation of assimilated C in fruit-bearing shoots throughout the development process, we constructed an in situ $^{13}$CO2 exposure polyethylene bag for stems and fruits of a Chinese jujube cultivar ‘Lingwuchangzao’. We used an infrared radiation equipment to control simulating elevated temperature environment, an automatic irrigation system to control soil water levels and the method of $^{13}$C labeling to measure assimilation of $^{13}$C in leaves and its translocation to the stems and fruits. Fruit-bearing shoots were sampled 12 h, 24 h and 7 days after exposure treatment, followed by analysis of $^{13}$C inventory in leaves, stems and fruits. We evaluated the translocation of

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**Specified Source(s) of Funding:** California Pistachio Research Board
Propagation (Poster)

Micropropagation of Nandina Domestica Thunb. Clones (Poster Board #310)

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Nandina domestica Thunb. (Berberidaceae) is an evergreen ornamental shrub with compact habit, colorful foliage, and wide adaptation to the landscapes and gardens in the southern US. Three newly selected clones with red, yellow and apricot foliage were trialed and desperately needed to be rapidly propagated for the market. Micropropagation was adapted and the youngest new growing tips with a naked bud were harvested as the explant. Contamination and bacteria invasion limited the third or earlier newly sprouted nodules as additional plant materials. Both red and apricot clones preferred 1/2MS basal salt while yellow one performed better under B5 without any vitriification. Both hormones, 1.0 mg/L benzylaminopurine (BA) and 2.0 mg/L gibberellic acid (GA3), were added to the initiation media. For multiplication stage, 1/2MS basal salt with hiziazuron (TDZ) at 0.05 mg/L helped red and apricot clones to reach the average multiplication rate of 7.7 in five weeks. For yellow clone, B5 with 0.03 mg/L TDZ yielded the highest rate of 3.0. Shoot length and number of shoots per cluster also significantly regulated the proliferation. Shoots of 2.5–3.0 cm long worked better for multiplication instead of 1.0 cm, 2.0 cm and > 3 cm. Two shoots per cluster could significantly improve the proliferation. Shoots longer than 3 cm didn’t proliferated well but could reach 100% rooting within one month on B5 medium plus 2.0 mg/L Indole-3-butyric acid (IBA). Newly selected clones of Nandina domestica could be regenerated by micropropagation and the multiplication rate was 3 or higher.

Chemotherapy with In Vitro Multiplication for Producing Strawberry Mild Yellow Edge Virus (SMYEV) Free Strawberry Plants from Infected Cultures (Poster Board #311)

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Producing virus free plants from infected plants is difficult using standard heat treatment/apical meristem excision procedures for virus elimination due to challenging technical aspects of the procedures and less than optimal growth conditions for plant cells. In this study, the use of the antiviral agent ribavirin (RIB) to produce strawberry mild yellow edge virus (SMYEV) free strawberry plants (Fragaria xananassa Duch.) from infected in vitro cultures was examined. Well developed in vitro strawberry crowns infected with SMYEV grown on modified Murashige and Skoog medium were used for each treatment. For the first treatment, 0.5 µM thidiazuron (TDZ) was added to the medium for 26 days, followed by 26 days with 200 µM RIB but without TDZ. These were then transferred to hormone and RIB free media for plantlet development. For the second treatment, the plantlets were cultured with RIB for 26 days without the TDZ pretreatment, and for the third treatment plantlets were multiplied with TDZ without RIB. After the treatments, plantlets were transplanted to the greenhouse over the next three-month period of the experiment as they became large enough. A total of 34, 87, and 50 plants from each respective treatment (TDZ then RIB; RIB no TDZ; and TDZ no RIB) were grown to maturity during the experiment in preparation for SMYEV testing by ELISA. Initial tests showed 2 (5.9%), 8 (9.2%), and 0 plants negative for SMYEV, respectively. Repeat testing of the putatively virus negative plants reduced the number to 1 (2.9%) and 6 (6.9%) virus negative plants. One plant, #76TDZ, was chosen as an explant donor to initiate new in vitro cultures because it produced numerous runners in the greenhouse suitable for culture initiation. After successful initiation and culture multiplication, five plants from the new culture were established in soilless media in the greenhouse for maturation. These plants subsequently tested negative for SMYEV. The combination of TDZ for rapid in vitro multiplication followed by ribavirin proved to be 2.3 times more effective at producing SMYEV virus free strawberry plants compared to culture without TDZ, and no virus negative plants were developed in the absence of ribavirin. The procedure is less technically demanding than heat treatment/apical meristem culture procedures for virus elimination and may be less likely to produce somaclonal variants commonly produced from apical meristem culture. It may also be a viable procedure for elimination of additional viruses in strawberry besides SMYEV.

Effects of Selected Media and Cytokinins on the Micropropagation of Vernonia Species (Poster Board #312)

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An asterisk (*) following a name indicates the presenting author.
The genus *Vernonia* Schreb., commonly known as ironweeds, comprises ≈ 1000 species worldwide and are widely known for their pharmaceutical qualities. Several species also have desirable ornamental characteristics. Many ornamental varieties are often difficult or slow to propagate through conventional methods such as stem cuttings or divisions. The development of micropropagation systems may facilitate faster propagation and the release of new varieties. In vitro regeneration studies on *Vernonia* have focused on medicinal species such as *Vernonia cinerea*. However little work has been done to develop in vitro propagation systems for ornamental species. Therefore, the objective of this study was to develop an efficient micropropagation system for a novel ornamental *Vernonia* hybrid and to examine the effects of selected media and cytokins on shoot proliferation. Multiplication was evaluated by culturing on either MS, WPM, DKW, Q&L or B5 basal salts. DKW produced the highest number of shoots (3.5 plants per explant), longest shoots (66 mm), and the highest multiplication rate (3.8-fold).

A second study evaluated the effects of cytokinins BAP, 2iP, meta-Topolin and TDZ at concentrations of 0, 1.25, 2.5, 5.0, or 10.0 µM. Explants cultured on media containing 2.5 µM TDZ produced the highest number of shoots (12.7 shoots per explant) and the highest multiplication rate (15.6-fold), while explants cultured on media containing meta-Topolin produced the longest shoots (86 mm). To test the long-term effects of TDZ, explants were maintained for 4 subculture cycles on 1.25, 2.5, 5.0, and 10.0 µM. At 1.25 and 2.5 µM TDZ, shoot regeneration increased to 27 fold during the second subculture period and remained high. For higher concentrations of TDZ, shoot multiplication rate and quality declined with increasing subcultures. Shoots from 1.25 and 2.5 µM formed roots in vitro and were successfully transferred ex vitro through 4 sub culture cycles.

**Developing a Modified Hydroponic Stock Plant System for Minicuttings of Redbud**

*(Poster Board #313)*

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Budding and micropropagation are the typical clonal propagation methods for difficult-to-root nursery crops. These methods can be more time consuming and expensive that cutting propagation. The forestry industry has adopted a commercially viable hydroponic stock plant strategy for difficult-to-root species that emphasizes plant nutrition and juvenility to establish cuttings that root at high percentages. A similar system was developed for a difficult-to-root nursery crops using eastern redbud (*Cercis canadensis*) as a model. Redbud stock plants grow vigorously in the modified hydroponic sand beds. It was determined that plants responded equally well when irrigated at full or half-strength nutrient solutions. Stock plants produce shoot growth that permitted cutting harvest every two to three weeks. The highest rooting for seedling and clonal cuttings was at 10,000 and 15,000 ppm auxin as a quick dip. Rooting was very similar for cuttings taken from hedged greenhouse and field-grown stock plants. Seedling cuttings were easier to root compared to cuttings from clonal plants. The highest rooting for clones was approximately 30% compared to 55% rooting in cuttings from seedling stock plants. Also, ‘Oklahoma’ cuttings consistently rooted at lower percentages than ‘Appalachian Red’. This research is supported by a grant from the Horticultural Research Institute.

**Specified Source(s) of Funding:** Horticultural Research Institute

**Speed in a Slow Lineage: The First Indole-3-Butyric Acid Dose Response Study on Cycads**

*(Poster Board #314)*

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An indole-3-butyric acid (IBA) dose response study was conducted on a model cycad species, *Zamia furfuracea* L.f.. Stem cuttings were subjected to one of five IBA concentrations within the range of 0–30,000 ppm in order to determine the IBA dosage that would induce adventitious root formation in the shortest amount of time. Stem cuttings were planted in perlite within clear containers, and the bottom surface of each container was checked daily until the first sign of root contact for each cutting. Less than two months were required to reach 50% rooting success. Cuttings receiving IBA dosages between 3000 and 16,000 ppm developed roots more quickly than the control cuttings. In contrast, cuttings receiving IBA of 30,000 ppm developed roots more slowly than the control plants. The results suggest that IBA between 16,000 and 30,000 ppm would be optimum for inducing adventitious roots most rapidly for this species. Published IBA dose response studies have been conducted on various angiosperm and a few gymnosperm species. To our knowledge, this is the first IBA dose response study for any cycad species. This information will inform cycad horticultural practices and add to an important conservation agenda, as cycads are the most threatened group of plants worldwide.

**Effects of Nutrient Salt Formulations and PGRs on Micropropagation of Cornelian Cherry**

*(Cornus mas L.)* *(Poster Board #315)*

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The utilization of tissue culture for rapid multiplication and micropropagation has become one of the fundamental ways ornamental plants are propagated for the nursery trade. *Cornus mas* L. (*Cornelian cherry*) is an underutilized ornamental landscape plant that boasts an early flowering habit and edible fruits. With

An asterisk (*) following a name indicates the presenting author.
it being an underutilized plant, little information regarding tissue culture of this species exists. The objective of this study was to evaluate and expand the micropropagation protocol developed by Đurković (2008). Đurković’s evaluation was limited, it did not focus on evaluating nutrient salt formulations and the impact on microshoot development and subsequent development. In this study, three different nutrient salt formulations were evaluated: Murashige and Skoog, Woody Plant Media, and LP. These nutrient salt formulations were compared in a factorial experiment with two plant growth regulators (PGRs): 6-benzylaminopurine (BA) and 1-naphthaleneacetic acid (NAA). The concentrations of the two PGRs used in the factorial were 0, 2, and 4 µM for BA and 0 and 0.5 µM NAA. The plant material used was 6-week-old explants of the cultivar ‘Schonbrunner Gourmet’ grown on LP medium supplemented with 2.0 µM BA and 0.5 µM NAA, 30 g/L sucrose, 7 g/L agar, and adjusted to a pH of 5.8. Each treatment was replicated seven times in both runs and the experimental design was a CRD factorial. Plantlets were subcultured three times at six-week intervals for a total of 18 weeks of incubation time. The LP medium supplemented with 2.0 µM BA and 0.5 µM NAA significantly performed better than the other media types with respect to shoot number and microshoot quality. This is contrary to Đurković’s claim that a modified WPM media is best for micropropagation of C. mas. In conclusion, micropropagation can be seen as a viable method for propagation of the species.

Catberry, Rhodora, and Sweetgale Vary in Their Responses to Auxin Treatment and Substrate Composition during Propagation by Stem Cuttings (Poster Board #316)
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Catberry (Ilex mucronata), rhodora (Rhododendron canadense), and sweetgale (Myrica gale) are three horticulturally promising shrubs of wetlands in North America. Although all three can be rooted from stem cuttings, root system quality may be inconsistent. To explore two factors that might improve quality of adventitious root systems, a minimum of 270 semi-hardwood cuttings of each species were collected in June or July 2016, treated with 0–15,000 ppm of the auxin K-IBA, and inserted into propagation media with 0, 25, or 50% peat moss by volume, with coarse perlite for the remainder. Cuttings were evaluated after eight weeks under intermittent mist. Rooting percentage of catberry cuttings was high, and averaged more than 80% across hormone treatments when either 25 or 50% peat moss was included in the medium; rooting averaged only 33% in perlite alone. Greatest root ratings, root lengths, root numbers, and root dry weights among cuttings of catberry occurred when they were treated with 5000–15,000 ppm K-IBA, and inserted into media with 25 or 50% peat. The use of perlite alone was unsatisfactory, as it caused catberry cuttings to proliferate callus excessively instead of rooting. Rooting percentage of rhodora cuttings averaged more than 90% when either 25 or 50% peat moss was included in the medium, but only 64% in perlite alone. Curves fit to these rooting responses showed that maximum root ratings, root lengths, and root dry weights can be obtained with concentrations of K-IBA between 5000 and 10,000 ppm for cuttings rooted in media containing peat. In contrast, cuttings inserted into perlite alone showed only modest gains in these measures when K-IBA was applied. Rooting percentage of sweetgale exceeded 80%, whether peat moss was included in the medium or not. The greatest average root ratings, root lengths, and root dry weights of sweetgale cuttings were produced when they were treated with 0–5000 ppm K-IBA. Although the number of roots on sweetgale cuttings did not vary markedly with K-IBA application, auxin concentration had a consistently negative effect on root elongation, root rating, and root dry weight. Collectively, these results show that media with 25 to 50% peat are appropriate for all three wetland species, and only sweetgale tolerates pure perlite during propagation. Catberry and rhodora respond well to concentrations of K-IBA exceeding 5000 ppm, whereas rooting in sweetgale is not enhanced, but may be diminished, by K-IBA application at concentrations used in this study.

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Vegetative Propagation of Lonicera caerulea var. villosa, a North American Blue Honeysuckle, by Overhead Mist and Subirrigation (Poster Board #317)
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One of many strategies available to limit the potential for future plant invasions is to introduce and promote the use of regionally native taxa for horticulture. As various honeysuckles (Lonicera spp.) of Eurasian origin have proven to be invasive outside their native ranges, we evaluated methods to propagate a potential North American alternative, mountain fly honeysuckle (Lonicera caerulea var. villosa). This species of northern climates has low population densities through much of its native range, and seems ineffective at displacing other species. Nonetheless, our observations of this plant in horticultural landscapes suggest that it could be used in landscapes more varied than its native distribution implies. To conduct propagation trials, we collected softwood terminal stem cuttings from plants indigenous to Maine in June 2017, treated each with one of several concentrations of potassium salt of indole-3-butyric acid (K-IBA), and stuck them into media with different proportions of perlite and milled peat moss. We conducted two separate experiments to independently evaluate the suitability of overhead mist or subirrigation during rooting. The percentage of cuttings that rooted was high and not significantly affected by treatments. Root dry weight, as well as root volume and number of root tips measured by scanning fresh roots and analyzing the images using WinRHIZO software, increased with concentration of applied K-IBA and proportion of perlite in the substrate. Within each system, K-IBA application

An asterisk (*) following a name indicates the presenting author.
Propagation Methods for Blue Elderberry
(Poster Board #318)

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Native to western North America, blue elderberry (*Sambucus cerulea* Raf.) is well adapted to the alkaline soils and short growing seasons of the arid, high elevation conditions found in the Intermountain West. However, domestication of this species for local fruit production has been hampered by difficulty in propagating superior selections. Experiments were conducted over four seasons to develop viable propagation protocols. Semi-hardwood cuttings from wild-grown plants collected at full bloom, and treated with a commercial NAA formulation had rooting success greater than 60%. The highest success rates (approaching 100%) were from two-node hardwood cuttings taken from greenhouse-grown stock plants. The cuttings were from the previous season’s growth, dipped in 0.2% NAA, and then cold callused for 14–18 weeks at 4 to 6°C before being placed in a greenhouse at 24°C/18°C (day/night) for six weeks. These methods will allow for commercial-scale propagation of blue elderberry for both the landscape and the specialty food products industries.

Adventitious Shoot Regeneration from Leaf Explants of Peach Rootstock ‘Hansen 536’
(Poster Board #319)

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‘Hansen 536’ {{*(Prunus davidiana × *P. persica)* × *P. persica ‘Okinawa’} × *P. amygdalus*} is an important commercial rootstock for peach and almond. However, susceptibility to wet soil and bacterial canker are the main disadvantages of this cultivar. Genetic engineering techniques offer an attractive approach to efficiently improve the problems existing in this cultivar. In this study, an efficient protocol for organogenesis regeneration from leaf explants were developed. Leaf explants were cultured on Murashige and Skoog (MS) and Woody Plant Medium (WPM) supplemented with different plant growth regulators to induce shoot regeneration. Nine potential media were evaluated and adventitious shoot regeneration occurred on five media at frequencies ranging from 0 to 34.5%. The optimal regeneration at a frequency of 34.5% occurred on the WPM medium containing 8.88 μM 6-benzylamino-purine (BA) and 1.97μM indole-3-butyric acid (IBA). The regenerated shoots were rooted successfully and transplanted to soil. This study provided a prerequisite for developing an efficient genetic transformation system.

Propagation and Evaluation of *Balduina angustifolia*, a Native Wildflower with Ornamental and Ecosystem Value
(Poster Board #320)

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Native plants have significantly increased in popularity over the last few years due to the demand for more environmentally suitable urban landscapes that are low maintenance (reduced water, fertilizer and pesticides), tolerant of Florida’s climate, and beneficial in supporting wildlife and pollinators. Consumers are also increasingly aware of the threat non-native invasive species pose to Florida’s ecosystems and are seeking native alternatives. *Balduina angustifolia* (Coastal Honeycombhead) is native to most of Florida and the coasts of Alabama, Georgia, and Mississippi. It is characterized as an herbaceous annual/biennial having green linear foliage, bright yellow ray and disk flowers, and persistent, honeycomb-shaped seed heads. Due to its charismatic nature and fall flowering time, *B. angustifolia* is a suitable candidate for introduction into the commercial ornamental plant industry. It is also an important pollinator species, attracting a number of butterfly and bee species, including the Florida endemic baldufina bee (*Hesperapis oraria*). The objective of this research was to evaluate the germination, flowering, and landscape performance of *B. angustifolia* under varying conditions. For the germination experiments, seeds were collected from two sites in the Florida Panhandle (Perdido Key and Navarre Beach) after overwin-
Crape myrtles provide a reliable source of color for many southern landscapes, often flowering for more than 100 days. Mississippi State University has released six new crape myrtle selections, including Shumaka™. Shumaka™ is a hybrid resulting from the cross of Lagerstroemia ‘Arapaho’ and an unknown pollen donor. Shumaka™ has a unique very light pink flower color and large growth habit. Three-year-old plants in a research setting are 20+ feet and have flowered from early June through late August. The bark is smooth to exfoliating, with outer bark that is grayish brown in color. The objective of this research was to evaluate ease of rooting and determine optimal commercial auxin formulation and concentration for hardwood cutting propagation of Shumaka™. Five-inch (12.7-cm) medial cuttings were harvested from the parent plant and inserted to a depth of 1 inch (2.5 cm) in propagation medium on 1 Feb. 2017. Propagation medium was 100% perlite placed in 3-inch (7.6-cm) containers. Treatments included two basal wounding treatments (wounded or non-wounded), three auxin formulations [Hortus IBA (Hortus IBA Water Soluble Salts™), Dip’n Grow® (IBA + NAA at 50% the rate of IBA), or Hortus IBA + KNAA (Hortus IBA Water Soluble Salts™ + NAA potassium salt at 50% the rate of IBA)], and three levels of auxin (0, 1000, or 5000 ppm IBA). Data collected after 60 days included rooting percentage, growth index (new shoots), cutting quality (0–5, with 0 = dead and 5 = transplant-ready cutting), total root number, average root length (of three longest roots), and root quality (0–5, with 0 = no roots and 5 = healthy, vigorous root system). Results showed that rooting percentage, number of roots, average length of the three longest roots, and growth indices were similar among treatment combinations. No benefits were observed from wounding of the cutting. Cuttings dipped in Hortus IBA did have better root quality compared to cuttings dipped in DNG; when Hortus IBA concentration was increased, root and cutting quality and root number increased. Overall, the results suggested that dipping Shumaka™ hardwood cuttings in Hortus IBA at 5000 ppm resulted in a higher quality liner.

Comparing Grafting Methods for Cornus Mas (L.) Clonal Propagation (Poster Board #322)

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A major limitation in a species or cultivar being sold to consumers is the initial propagation required to produce genetically identical plants. *Cornus mas* (L.) is a dogwood native to eastern Europe where it has historically been used in foods such as preserves and pies. It has promising aspects for edible landscaping (ediscaping) and is an overall quality plant. With its high disease and pest resistance, it makes for a great species to include in a landscape for diversity. However, *C. mas* is an underutilized species in the United States and therefore information on propagation techniques is lacking. Many woody plant species are propagated using grafting or budding onto a rootstock to maintain genetic homogeneity. The only available research on grafting for *C. mas* was performed in a nursery field rather than in a greenhouse (Bijelić et al., 2016). While Bijelić tested two different graft types (bud and whip) at separate times of the year (spring whip grafting in April and bud grafting in August), this study tested two graft types in a factorial of different times of the year. Two selections were used for this study; ‘Pyramidalis’ and an individual (TS79239) from the NDSU Research Arboretum [near Absaraka, ND (lat. 46°9859′; long. –97°3549″)]. The graft types used were the side graft and the chip bud graft. Two runs were
conducted on 13 Apr. 2017 and 19 Apr. 2017. The experiment was a CRD factorial consisting of graft type by selection. Each treatment had five replicates. The side graft had a significantly higher success rate (100%) as compared to chip bud graft (40%). The side graft had a significantly higher grafting success rate as reported by either methods by Bijelić et al. (2016). There was no significant difference between germplasm selections with respect to grafting success. The experiment was attempted again in late August with no success in either type of graft or selection. It is unclear whether or not the failure of the late summer runs was caused by the rootstocks going dormant. It can be concluded from this study that grafting is an effective way of propagating C. mas using the side graft method on rootstocks in the spring.

Dormant Propagation of Neshoba™ Crape Myrtle (Poster Board #323)

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Mississippi State University has developed several new crape myrtle selections, including Neshoba™. Objective was to determine optimal hormone source and concentration for hardwood cutting propagation of Neshoba™. Medial cuttings (12.7 cm) were harvested and stuck to a depth of 2.6 cm on 1 Feb. 2017. Medium was 100% perlite in 7.6 cm containers. Treatments included two basal treatments (wounded or non-wounded), three hormone mixtures (Hortus IBA, Dip & Gro, or Hortus IBA + NAA), and three levels of hormone (0, 1000, or 5000 ppm IBA). Experimental design was a RBCD with five single plant replications. Data collected included percent rooting, new shoot growth, cutting quality, root number, average root length (length of three longest roots/three), and root quality. Cuttings dipped in Hortus IBA 5000 ppm, regardless of basal treatment, had more roots compared to controls, or non-wounded Dip’N Grow 1000 ppm. Non-wounded cuttings dipped in Hortus IBA 1000 ppm had higher root quality compared to all cuttings except those wounded and dipped in Hortus IBA 5000 pm or non-wounded and dipped in Dip’N Grow 5000 ppm. Cutting quality was greater for wounded cuttings dipped in Hortus IBA 5000 ppm compared to wounded control, non-wounded and dipped in Dip’N Grow 1000 ppm, wounded and dipped in Dip’N Grow 5000 ppm, or non-wounded and dipped in Hortus IBA 5000 ppm + KNAA 2500 ppm. Growth was greater for cuttings that were wounded and dipped in Hortus IBA 5000 ppm compared to controls or cuttings dipped in Dip’N Grow 5000 ppm, non-wounded and dipped in Hortus IBA 1000 ppm + KNAA 500 ppm, or non-wounded and dipped in Hortus IBA 5000 ppm + KNAA 2500 ppm. When direct comparisons were made, wounding, increasing concentrations of Dip’N Grow or Hortus IBA + KNAA had no influence on measured characteristics. Cuttings treated with hormone had more roots compared to controls, but increasing hormone concentration only resulted in additional roots for cuttings dipped in Hortus IBA. Cuttings dipped in Hortus IBA had higher root and cutting quality ratings compared to controls, those dipped in Dip’N Grow, or Hortus IBA + KNAA. Cuttings dipped in Hortus IBA had greater growth compared to controls or cuttings dipped in Hortus IBA + KNAA. Results suggest hardwood cuttings of Neshoba™ crape myrtle may be successfully rooted without wounding or use of auxin, but use of Hortus IBA did improve cutting quality and growth.

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Four Grafting Techniques and Their Impact on Success Rate in Pawpaw (Asimina triloba) (Poster Board #324)

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The pawpaw (Asimina triloba) is a fruit bearing tree native to North America. Its rising popularity has led to small-scale commercial production in the United States and worldwide. There is growing interest from processors, retailers, and restaurants. A large number of wild and seedling pawpaws grown by homeowners and small farmers produce fruit of poor taste, quality, or size. Two new advanced selections, Hi7-1 and Hi4-1, being studied at Kentucky State University (KSU) have shown more favorable reviews about flavor, texture, and appearance than many commercially available varieties. KSU-Atwood is a

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Vegetable Breeding 1 (Poster)

Evaluation and Association Analysis of Downy Mildew Resistance in USDA Spinach Germplasm (Poster Board #038)

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Downy mildew, caused by the plant fungal pathogen Peronospora farinosa f. sp. spinaciae (Pfs), is an important disease of spinach, particularly for Spinacia oleracea, the most commonly cultivated spinach species in United States and Europe. To date, 16 races of the downy mildew (DM) pathogen are recognized but new isolates are continuously emerging each year. The ability of new strains of the pathogen to overcome resistance in spinach plants makes the development of spinach varieties with increased levels of resistance to Pfs challenging and essential. Genome wide association mapping offers a promising tool to identify QTLs associated with downy mildew resistance against emerging new races of Pfs. The identified QTLs can be readily used to improve genetic resistance against downy mildew disease in spinach. A total of 481 spinach genotypes are evaluated to identify potential resistant germplasm to be used in spinach breeding programs. The evaluated population will be subjected to genome wide association mapping. As a result of this study, SNP markers for downy mildew resistance will provide breeders with a tool to select resistant plants and lines in spinach against downy mildew resistance. Downy mildew, caused by the plant fungal pathogen Peronospora farinosa f. sp. spinaciae (Pfs), is an important disease of spinach, particularly for Spinacia oleracea, the most commonly cultivated spinach species in United States and Europe. To date, 16 races of the downy mildew (DM) pathogen are recognized but new isolates are continuously emerging each year. The ability of new strains of the pathogen to overcome resistance in spinach plants makes the development of spinach varieties with increased levels of resistance to Pfs challenging and essential. Genome wide association mapping offers a promising tool to identify QTLs associated with downy mildew resistance against emerging new races of Pfs. The identified QTLs can be readily used to improve genetic resistance against downy mildew disease in spinach. A total of 481 spinach genotypes are evaluated to identify potential resistant germplasm to be used in spinach breeding programs. The evaluated population will be subjected to genome wide association mapping. As a result of this study, SNP markers for downy mildew resistance will provide breeders with a tool to select resistant plants and lines in spinach against downy mildew resistance.

Specified Source(s) of Funding: USDA SARE

Biochemical and Molecular Events Underlying Cucumber Resistance to Downy Mildew (Pseudoperonospora cubensis) (Poster Board #039)

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Downy mildew caused by the oomycete Pseudoperonospora cubensis generates significant yearly losses of cucumbers and with increased levels of resistance to Pfs challenging and essential. Genome wide association mapping offers a promising tool to identify QTLs associated with downy mildew resistance against emerging new races of Pfs. The identified QTLs can be readily used to improve genetic resistance against downy mildew disease in spinach. A total of 481 spinach genotypes are evaluated to identify potential resistant germplasm to be used in spinach breeding programs. The evaluated population will be subjected to genome wide association mapping. As a result of this study, SNP markers for downy mildew resistance will provide breeders with a tool to select resistant plants and lines in spinach against downy mildew resistance.

Specified Source(s) of Funding: USDA’s National Institute of Food and Agriculture
related crops in Poland and worldwide. In our study, we chose five cucumber cultigens showing a broad range of *P. cubensis* reactions, and submitted them to laboratory bio-assays with an aggressive local pathogen isolate, to observe the important subcellular, biochemical, and transcriptomic reactions. DCFDA staining evidenced participation of the reactive oxygen species (ROS) in response to *P. cubensis* infections. An increasing proportion of ROS was found over time, with only a slight increase in their content in the resistant cultigens compared to the susceptible ones. Differences in the activity of SOD, PPO, and POX, corresponded with the *P. cubensis* resistance level of the tested cultigens. The resistant cultivars showed a significant increase in enzymatic activity at 8 hours after inoculation (hpi), whereas the susceptible ones displayed such increase only after 36 hpi. In case of the protective substances, there was an upward trend in the content of free phenols and lignins, with a clearer tendency in the resistant cultigens. Transcriptomic analyses included qPCR investigations of 19 cucumber transcripts (salicylic acid related: 2; jasmonic acid related: 4; PR genes: 8; PAL; LOX; CalSyn; VPE) normalized to housekeeping genes. All these analyses pointed to a comparatively earlier activation of the defenses in the *P. cubensis*-resistant cultigens.

**Genetic Analysis of Young Fruit Resistance to Phytophthora Capsici in Cucumber (Poster Board #040)**

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Phytophthora blight caused by *Phytophthora capsici*, a soil-borne pathogen, can be a devastating disease for cucumber. In cucumber, *P. capsici* specifically infects fruit, especially young fruit, leaving vines and leaves uninfected, necessitating a search for resistance in young fruit. The objective of this work is to identify quantitative trait loci (QTLs) associated young fruit resistance to *P. capsici* in cucumber. Cucumber accession, PI 109483, was previously identified as a source of resistance. The S1 generation (line 109483-53) was used for doubled haploid (DH) production, and three resistant lines selected. The S6 generation (109483-53 B5) was crossed with the susceptible pickling cucumber inbred line, Gy14, to develop F1 and backcross populations. In the summer of 2017, 400 progeny from the F1 population [(Gy14 x A4-3)x] along with parent lines and F1 were screened in the field. In order to facilitate accurate phenotyping, plants were trellised to reduce contact of the fruits with the soil. This reduced wounding that can occur during the cleaning process to remove soil prior to inoculation, as well as lessening the probability of cross-contamination resulting from other pathogens in the soil. Harvested fruits were sanitized with 1% bleach, placed in sealed trays to maintain high humidity, and inoculated with 1 x 104 zoospores/mL of *P. capsici* isolate Bartley’s 1. For the initial stage of screening, three replicate harvests were performed providing 5-25 fruits for each plant. The normal distribution of disease scores for the F2 population indicated that young fruit resistance is a quantitative trait. Based on the initial result, the top and bottom 12% of plants were selected. Fruits were harvested from these individuals three additional times and inoculated with an elevated pathogen concentration (5 x 104 zoospores/mL). The results from re-screening showed reproducibility of the disease scoring and accuracy of selection. To provide a second population for QTL-seq analysis, 400 F2 progeny derived from DH line (A4-3) [(Gy14 x A4-3)x] is currently being phenotyped in the greenhouse. For QTL-seq analysis, 15 resistant and susceptible individuals will be selected from each F2 population. DNA will be extracted and pooled for sequencing and analyzed for QTL to determine genomic regions associated with the resistance.

**Specified Source(s) of Funding:** Polish Ministry of Agriculture and Rural Development

**Breeding for Fusarium Basal Rot Resistance in Short-day Onions (Poster Board #041)**

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Fusarium basal rot (FBR), caused by a soil-borne fungus *Fusarium oxysporum* f. sp. *cepeae* (FOC) is one of the most devastating diseases of onion worldwide. FBR disintegrates the compressed stem and is particularly damaging to the bulbs in storage, as the initial decay is difficult to detect. The development of resistant cultivars could be the best possible alternative over the conventional methods to control FBR, viz., crop rotation and soil fumigation, allowing farmers to utilize the same fields for multiple crops without the need for soil fumigation. Failure to increase FBR resistance via seedling and field screening methods, which were used to develop FBR-resistant long-day and intermediate-day cultivars, the New Mexico State University onion breeding program used a mature bulb screening method to evaluate selected populations of seven short-day Grano-type cultivars originated from two different artificial inoculation mature bulb selection processes. Transversely-cut basal plates were inoculated with PDA plugs containing different concentrations of spore suspensions of a virulent FOC isolate ‘CSC-515’. After 20 days of incubation, 20 randomly-selected inoculated bulbs were cut transversely again to measure FBR severity and incidence percentage. A high disease severity and incidence observed during both 2016 and 2017 seasons that could be linked to congenial disease causing environments in addition to higher spore concentrations. The advantage of using a spore inoculation as compared to a mycelium plug inoculation was realized in 2017, when a reduced disease severity and incidence was observed in FBR3, FBR1-2 and selected populations of the checks, all generated by the former method. A further evaluation of the old and newly-selected populations is underway along with a digital image analysis for objective scoring and screening based upon antifungal secondary metabolites.

An asterisk (*) following a name indicates the presenting author.
**Novel Sources of Resistance to Florida Isolates of Bacterial Leaf Spot in Lettuce (Lactuca sativa L.)** *(Poster Board #042)*

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Bacterial leaf spot (BLS) caused by the bacterium Xanthomonas campestris pv. vitians (Xcv) affects yield and quality of lettuce production in North America. Due to unpredictable nature of outbreak, preventive and post-infection control of the disease are impractically expensive. Therefore, breeding lettuce with high resistance to BLS is a priority for public and private breeding sectors. In Florida, environmental conditions are conducive for disease development, due to the high humidity and temperatures. In conditions favorable for disease development, the entire crop may be lost. During the season of 2017–18 we recovered five new isolates of Xcv which caused disease outbreak in susceptible lettuce cultivars. Our previous tests indicate that plant introduction (PI) 358001-1 has complete resistance to Florida strains of BLS. PI is a leaf-type lettuce that bolts faster than commercial cultivars used at the EAA (Everglades Agricultural Area). Breeding efforts are in place by the University of Florida to transfer the resistance from this PI into romaine and crisphead lettuce. The lettuce breeding program of the University of Florida continues to screen lettuce PI's and cultivars from the National Plant Germplasm System (NPGS) of the GRIN — USDA to identify additional sources of resistance. Fifty-eight PI's and seven cultivars were tested with two isolates of BLS collected in Florida; with the resistant PI 358001-1 and susceptible ‘Okeechobee’ as controls. Significant differences were found in disease severity of tested material when inoculated with isolates Sc8b ($P < 0.0001$) and L7 ($P = 0.0136$). PI's 278080, 342898, 667690, and 'Batavia Reine des Glaces' showed none to minimal disease when inoculated with isolate Sc8b; PIs 342516, 419088, 601115 612665, 667709, 667690 and cv. La Brillante were as resistant as PI 358001-1 when inoculated with isolate L7. Furthermore, 44 PI’s plus 6 cultivars were tested in California for their reaction to isolate BS0347. ‘La Brillante’ and PI 251246 were used as resistant and susceptible controls, respectively. Significant differences ($P < 0.0001$) in disease severity were found among accessions tested in California. PIs 278080, 342441, 342473, 591052,657639, 665198, 665203, 667690, and 667709 did not show any disease symptoms or were as resistant as the check cv. ‘La Brillante’. Further tests are needed to confirm these findings and to assess if resistance in PIs 278080 and 6667690 is strain specific. Accessions with resistance to multiple strains of the pathogens could be used in Florida and California lettuce breeding programs.

*Specified Source(s) of Funding:* Specialty Crop Block Program. Florida Department of Agriculture & Consumer Service

**Fine Mapping of the Tomato Spotted Wilt Virus-resistance Gene Sw7** *(Poster Board #043)*

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Tomato spotted wilt virus (TSWV) is an economically damaging pathogen of tomatoes. Typical symptoms of TSWV include wilting or stunning plants and chlorotic or necrotic rings on leaves and fruits. The symptoms can cause yield losses. The precise positioning of TSWV resistance genes on genetic maps is critical for improving the effectiveness of marker-assisted selection (MAS). The objective of this study was to fine map the TSWV resistance gene Sw7 from S. chilense accession LA1938. The fine mapping was initiated by identifying recombination events from F2 plants using molecular markers. Four different types of co-dominant molecular markers including high resolution DNA melting analysis (HRM) based on single nucleotide polymorphisms (SNPs) were used. The rate of natural thrips-vectored TSWV infection was evaluated in field trials conducted in Florida (2007, 2011, 2012, 2013) and Hawaii (2014). Further, whole genome sequencing (WGS) of two resistant breeding lines, Fla. 8516 and Fla. 8820, and plotting of SNPs and insertions and deletions of DNA segments on tomato chromosomes were conducted to identify the introgression of the wild tomato genome. Together, TSWV resistance gene Sw7 has been fine mapped into 4.0-Mbp interval close to the telomere (within 10% of the chromosome length) on tomato chromosome 12.

**SNP Markers Linked to QTL for CMVP1 Resistance in Chili Pepper (Capsicum annuum L.)** *(Poster Board #044)*

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Viral diseases severely limit the production of vegetable crops, and Cucumber mosaic virus (CMV) is one of the most recurrent...
viruses in chili pepper (*Capsicum annuum* L.) worldwide. An extensive host range and diverse pathogen strains make CMV control difficult in the field hence CMV-resistant pepper variety is required. In this study, we developed SNP markers linked to the QTLs for CMV~p~ resistance through genotype-by-sequencing (GBS) and high-resolution melting (HRM) analyses. The single seed descent (SSD) F3 segregating population obtained from a cross between a resistant line ‘A1’ and a susceptible line ‘2602’ was assessed for CMV~p~ resistance. The individuals were inoculated with CMV~p~ strain, and 30 days after inoculation the phenotype was confirmed by RT-PCR. A total of 96 individuals including 48 resistant and 48 susceptible plants were selected for GBS analysis. QTL analysis with composite interval mapping (CIM) exhibited two QTLs, *cmvP1*-5.1 and *cmvP1*-10.1, resistant to CMV~p~, detected on chromosome 5 and 10, respectively. SNP markers linked to these two QTLs were developed by performing HRM analysis. For validity test of the HRM markers, an SSD F5 population of the same cross was used and evaluated. In chromosome 5, a total of 20 markers were developed and mapped, and QTL analysis revealed a marker SNP07838 with LOD value 7.0 strongly linked to CMV~p~ resistance. In addition, a total of 15 markers on chromosome 10 were developed, and a marker SNP13607 with LOD value 3.2 was detected by QTL analysis. These two SNP markers are expected to be useful for pepper breeding with CMV~p~ resistance.

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**Examinations in Heat Inheritance and the *lov* locus in Chile Pepper** *(Poster Board #045)*

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Chile pepper (*Capsicum* sp.) has important economic and cultural significance worldwide. One of its most distinctive attributes is the burning sensation when consumed. This heat sensation is caused by a class of alkaloid compounds known as capsaicinoids that typically accumulate in vesicles located on the placental walls of mature fruit. Several studies have been conducted on the genetics of heat inheritance in chili pepper. A single, dominant gene, *Pun1*, plays a role in the production of capsaicinoids in *C. annuum*. A second locus is suspected of controlling the production of vesicles in the placental wall. The locus, termed the “loss of vesicle” gene (*lov*), is the explanation for a no-heat phenotype in some *Capsicum* species. In this study, a segregating population constructed using two no-heat parents, *C. annuum* bell-type, ‘Jupiter’, and the commercial F1 cultivar, ‘Paladin’, were hybridized. ‘Jupiter’ has vesicles and is no-heat. ‘Paladin’ displays a smooth placental wall (i.e., no vesicles) and is heterozygous at the *Pun1* locus. The F1 progeny displayed a hot phenotype, and were selfed and the subsequent F2 generation was evaluated. Fruit in the F2 population segregated displaying three phenotypes: hot with vesicles, no-heat with no vesicles, and no-heat with vesicles. The segregation did not fit the expected phenotypic ratio 9:4:3. Results suggest that vesicle production is a quantitative trait. This also proves that capsaicinoid production and vesicles production are independent genes. This study provides further insight into the various modes of heat production in *Capsicum* and will aid breeding programs with cultivar development.

**Development of Heat Tolerant Chili Variety through Marker-assisted Backcrossing** *(Poster Board #046)*
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Marker-assisted backcrossing contributes significantly to get over the main drawbacks in the ancient manual breeding approach (conventional) and speeds up the genome recovery of the recurrent parent (RPG). Recently, chilli output in Malaysia plunged due to El Nino, leading to the shortage of supply. El Nino is a complex series of climatic changes that occurs irregularly and affects sea surface temperature in most tropics and subtropics. To increase production there is the need to improve/produce varieties having high yielding potentials as well as tolerance against high temperature that will be suitable for lowland cultivation. The strategy was adapted to introgress *Hsp* genes from AVPP0702, donor, into the genetic profile of Kulai variety, recipient. Parents were crossed and backcrossed to generate F1 hybrids and backcross generations. Sixty-eight markers appeared to be polymorphic between the parents and used to assess the backcross generations; BC~F1~, BC~F2~, BC~F3~, and BC~F8~. The average RPG percentage of the recurrent parent in BC~F1~, BC~F2~, BC~F3~, and BC~F8~ was found to be 81, 90, 95 and 97% respectively. To confirm the presence of *Hsp* genes, gene expression analysis was carried out for the selected plants with high recovery of the recurrent parent. Polymorphic *Hsp*-linked markers were identified between the parents, F1, BC~F1~, BC~F2~, BC~F3~, and BC~F8~, and their *Hsp* expression levels (up-regulated with more than 4-fold increase) were similar with the donor parent indicating successful introgression of the target gene. Furthermore, selected BC~F1~, BC~F2~, plants were evaluated for agro morphological performance which was found to be similar with the recurrent parent. Improved high-yielding heat tolerant chilli lines showed tolerance to high temperature as well as did not express any negative effect on agronomic traits in comparison with Kulai variety. It is expected that the newly developed heat tolerant lines would increase chilli production to enhance and sustain future livelihoods and food security in...
Malaysia and other heat prone areas vis-a-vis climate change.

*Specified Source(s) of Funding:* Ministry of Higher Education, Malaysia

**Vegetable Crops Management 1 (Poster)**

**Evaluation of Vertical Grow Tower for Organic Leafy Greens Production** *(Poster Board #001)*

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Vertical tower is an aeroponic vertical standing structure that allows plant growth without chemical pesticides, herbicides or soil. Vertical towers save land, space, and water; produce no weed, pest or disease issues; and are ecofriendly. The objective of this preliminary research trial was to evaluate the yield performance of green leafy vegetables. Five crops, Mustard, Swiss Chard, Collard, Kale and Lettuce, were grown in Summer 2017 at the Tennessee State University organic farm. Organic seeds were started in planting trays in an organic potting mix in a greenhouse. Transplants (3 weeks old) were transferred onto rock wool cubes (2.5 cm) in an indoor vertical grow tower, 62 inches tall in a 3 square feet unit area. A tower held up to 20 plants each in 20 evenly spaced compartments. There were four compartments for each vegetable type in each tower. The experiment was replicated in a second tower and both towers were spaced a few feet from each other. Water and nutrient solution were administered to the plants using an inbuilt pump within the tower system. Vegetables were harvested at maturity and total fresh weight per plant was recorded for each tower. The Giant Mustard produced 154.38 g, the Pink Russian Swiss Chard yielded 141.50 g, Georgia Collard yielded 132.50 g while the Lacinto Kale and Parris Island Romaine Lettuce produced yields of up to 110.63 g and 96.88 g, respectively. The preliminary trial confirms that the vertical grow tower can serve as a viable alternative to growing vegetables horizontally on land as it uses less space and increases number of vegetables produced per unit area, due to the higher number of plants obtainable per growing floor area.

*Specified Source(s) of Funding:* Hatch

**Does Fruit Cluster Pruning Improve the Yield and Quality of Organic High Tunnel Tomatoes?** *(Poster Board #003)*

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The successful production of high-quality, high-yielding crops is important for fruit and vegetable producers, especially growers who use high tunnels. The valuable space within a high tunnel is well-suited to organic farming and can be used to grow many specialty crops. Fruit load management is practiced in tree fruit production (e.g. apples and peaches), but there is little consensus concerning the effectiveness of fruit cluster pruning on tomato *(Solanum lycopersicum)* when considering its impact on yield, quality, and marketability. There is also no research on tomato cluster pruning within organic systems, intensively-managed high tunnels (e.g. densely-planted, trellised, vegetatively pruned plants), or the Front Range of Colorado. The objective of this research was to address and add to the present knowledge of production techniques for cultivating indeterminate tomatoes in a high tunnel under organic management. In 2016 and 2017, a randomized complete block design was used to test the effects

An asterisk (*) following a name indicates the presenting author.
of cluster pruning within a high tunnel on certified organic land at Colorado State University’s Agricultural Research, Development, and Education Center (ARDEC) South. Two treatments and three cultivars of tomato were selected for the study; the treatment-cultivar combinations were replicated six times within a high tunnel. The treatments involved reducing fruit loads to three fruits and six fruits per cluster while plants with unpruned clusters, which developed up to ten fruits, served as the control. Tomato cultivars evaluated were Cherokee Purple, a widely-studied heirloom, and hybrids Jet Star and Lola. Parameters measured included total yield, individual fresh fruit weight, soluble solids content, marketable yield, and non-marketable yield. Each plant was trained to have a single leader, a useful technique allowing for high-density production. Averaged over two growing seasons, individual fresh fruit weight increased for both hybrids in the three-fruit treatment, but ‘Cherokee Purple’ did not respond positively or negatively to treatments. There was no decrease in total yield between treatments and the unpruned control; however, cultivars performed differently with ‘Jet Star’ yielding more than the other two cultivars. Soluble solids content and marketability measurements were more influenced by cultivar than cluster pruning treatments. ‘Jet Star’ had the highest marketable yields of all cultivars tested while ‘Cherokee Purple’ produced larger non-marketable yields. In summary, cluster pruning produced larger organic tomatoes without reducing yield or quality for two of the three cultivars used in the study. Cultivar selection remains one of the largest factors in determining yield, quality, and marketability of a crop.

Specified Source(s) of Funding: Colorado State University Department of Horticulture and Landscape Architecture; CSU Agricultural Experiment Station

Effects of Grafting with Estamino and Multifort on Yield and Plant Growth Parameters of Tycoon and Tamu Hot Tomato under Field Conditions (Poster Board #004)

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An experiment was carried out in Overton, TX in spring 2017 to test the effects of commercial tomato rootstocks on growth and yield performance of determinate tomato (Lycopersicon esculentum) varieties. The Overton trial was part of an internal statewide grant funded by Texas A&M AgriLife Research (led by Daniel Leskovar) with trials conducted in 4 locations in Texas. to understand regional performances that would benefit all Texas producers. Results in this poster reflect only the field trial conducted at Overton on Kirvin fine sandy loam soil. The experiment consisted of two scions (TAMU Hot and Tycoon) grafted on two rootstocks (Estamino and Multifort) with non-grafted scions as controls for a total of 6 treatment combinations. The experimental design was a RCBD with 4 replications and eight plants per treatment—replication with a total of 196 plants. Transplanting was conducted on 21 Mar. and the trial was terminated on 11 July after six harvests. A fertilization program by Vital Fertilizer Co. was adopted. Pest and disease control followed local recommendations by Texas A&M. Data collected consisted of: number of fruits per plant, marketable and total yields, and final shoot dry weight and leaf area. Results indicated that grafting significantly increased total and marketable yields, and total and marketable number of fruits per plant for Tycoon, but not for TAMU Hot. Marketable yield ranged from 54.1 for non-grafted Tycoon to 81.4 Mg/ha for Tycoon-Estamino combination. No significant differences in average fruit weight were observed between grafted and non-grafted Tycoon plants, while that of Multifort rootstock was significantly higher than non-grafted TAMU Hot. There were no statistical differences in fruit or shoot dry weights among all treatments. Leaf area was highest with Tycoon-Multifort combination and lowest with TAMU Hot non-grafted, with no significant differences among other treatments.

Performance of Seedling Grafted Tomato Plants Grown in Northern Climate (Poster Board #005)

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Influence of tomato seedling grafting on the growth, fruit yield and quality, and plant health was investigated using three cultivars (Big Beef, Celebrity, Cannonball) as scions and two rootstock cultivars (Blocking, Maxifort). Plants of most graft combinations outperformed non-grafted plants in terms of plant size, number and quality of fruits harvested, and general foliage health. The number of days required for first flowering was significantly delayed in grafted plants of ‘Cannonball’/‘Maxifort’ (60 days) and ‘Celebrity’/‘Maxifort’ (61 days) compared to non-grafted ‘Cannonball’ (57 days) and ‘Celebrity’ (54 days) plants. Similarly, the days to fruit maturity for ‘Cannonball’/‘Maxifort’ (95 days) and ‘Celebrity’/‘Maxifort’ (92 days) were significantly greater than their non-grafted counter parts ‘Cannonball’ (84 days) and ‘Celebrity’ (86 days). The yield, average weight of fruits and number of fruits per plant in ‘Big Beef’/‘Maxifort’ (10.4 kg/plant, 0.5 kg/fruit, and 33 fruits/plant) were significantly higher than the non-grafted ‘Big Beef’ (2.3 kg/plant, 0.2 kg/fruit, and 9.4 fruits/plant). Grafted plants were taller than non-grafted plants as shown by ‘Big Beef’/‘Maxifort’ (137 cm) and ‘Big Beef’/‘Blocking’ (127 cm) as compared to Big Beef (94.8 cm). The number of fruits per plant in grafted plants (33 fruits in Big Beef/‘Maxifort’, 23 fruits in Big Beef/‘Blocking’) was greater than that in non-grafted plants (10 fruits in ‘Big Beef’). In general, fruits harvested from grafted plants had slightly higher sugar
Effects of Phosphorus Nutrition on the Anthocyanin Concentration and Foliar Coloration of Lactuca sativa (Poster Board #006)

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Phosphorus (P) nutrition in plants can influence foliar coloration, typically due to increased concentrations of pigments such as anthocyanins. The foliar coloration of edible crops can affect their aesthetic appeal, perceived health benefits, and overall marketability to consumers. We conducted this study to record the effects of P fertilization on the leaf color, chlorophyll content, and anthocyanin concentration in ‘Salanova® Red Butter’ lettuce (Lactuca sativa L.). At the beginning of the first experiment, we fertilized the lettuce with P concentrations of 0, 2.5, 5, 10, and 20 mg·L⁻¹ P. After three weeks, half of the plants from each non-zero concentration were restricted to 0 mg·L⁻¹ P. We took biweekly measurements of height, diameter, and chlorophyll content, and a final determination of anthocyanin concentrations. Plants grown with low or no P for the duration of the study were dark purple in coloration with high concentrations of anthocyanins. However, these plants were extremely stunted and had developed severe necrosis on the lower leaves. Plants grown initially with 2.5–10 mg·L⁻¹ P but later restricted to 0 mg·L⁻¹ P also developed necrosis on the lower foliage. Lettuce grown with 20 mg·L⁻¹ P for the duration of the study were greener in coloration, but were also the largest. Based on these results, we conducted a second experiment in which we used nine total treatments of 2.5, 20, and 40 mg·L⁻¹ P for the duration of the study, and 20 or 40 mg·L⁻¹ P restricted to 2.5 mg·L⁻¹ P after 3, 4, and 5 weeks. Regression demonstrated trends in plant size, weight, chlorophyll content, and anthocyanin concentration in response to P nutrition. Commercial lettuce growers can manipulate P fertilization in order to enhance the red pigmentation of ‘Salanova® Red Butter’ lettuce, but this may come at the cost of decreased fresh weight and deficiency symptoms if nutrition is not monitored sufficiently. Growers implementing this fertilization strategy should use ≥ 20 mg·L⁻¹ P during the first half of production, and then lower the P fertility 3 weeks before harvest. Further refinement and cultivar trialing is necessary to improve fertility recommendations for red lettuce.

Specified Source(s) of Funding: NDDA Specialty Crop Block Grant
results show that supplemental lighting and its spectral quality have a significant effect on the growth and the phytochemical content of lettuce and the response, however, varied depending on the variety.

Specified Source(s) of Funding: USDA-NIFA

**Supplemental Untraviolet Light Affects Plant Growth and Nutritional Quality of Lettuce, Spinach, and Tomato** *(Poster Board #008)*

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A greenhouse study was conducted to examine the effects of supplemental ultraviolet light (UV-A and UV-B) on the nutritional quality of lettuce (*Lactuca sativa* L. ‘New Red Fire’ and ‘Two star’), spinach (*Spinacia oleracea* ‘Bloomsdale’), and tomato (*Solanum lycopersicum* L. ‘BHN-589 F1’). Three-week-old plants were transferred to a greenhouse and grown under full sun with supplemental UV light. The plants were exposed to UV just prior to harvest and nutritional quality was determined by mineral nutrient composition and phytochemical content in edible parts of the plants. The plants were subjected to UV treatment consisting of UV-A (8.11 W/m²), UV-B (1.97 W/m²), UV-A+UV-B (5.08+1.55 W/m²) for various lengths of time. Supplemental UV did not affect the biomass accumulation, leaf area or the leaf-shape index in green-leaf lettuce (Two Star). However, in red-leaf variety (New Red Fire), UV-B and UV-A+UV-B suppressed leaf area, but not the biomass accumulation compared to UV-A treatment and the control. In addition, the total phenolic content and antioxidant capacity in red-leaf variety were significantly higher under UV-A compared to the control, although there were no significant differences in green-leaf variety. UV increased the leaf concentration of Ca and Mg in both varieties of lettuce, and N only in green-leaf variety. Similar response was observed in spinach where UV increased Ca, Mg and N levels along with P, S, and Cu. However, no significant increase in phytochemical content was observed. While N content of green-leaf varieties (in both leafy vegetables) increased there was a significant decrease in carbon accumulation in response to UV exposure. With regard to tomato fruits, UV exposure did not significantly affect the fruit yield or the total phenolic content. The results show that the UV effect on growth and nutritional quality among leafy vegetables is quite variable, and thus, further analyses with regard individual phenolic and carotenoid compounds are being conducted.

Specified Source(s) of Funding: USDA-NIFA

**Passive Diurnal Temperature Manipulation Effects on the Growth, Pigmentation, and Consumer Response to Spring and Fall High Tunnel-grown Red Lettuce (**Lactuca sativa**)** *(Poster Board #009)*

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Detailed study in highly controlled environments featuring active temperature maintenance and supplemental lighting has helped explain the influence of light and temperature on lettuce primary productivity and secondary metabolite levels. However, crop responses in moderately and passively manipulated environments important to a large and increasing number of growers are less clear. Responses by high tunnel-grown baby red lettuce experiencing diurnal temperature fluctuations modified by day and/or night aerial coverings during the dynamic spring and fall periods are particularly under-investigated. In this study, twenty 4.47-m² wood-framed beds containing a soil-based medium within a 9.1 m × 24.4 m single-layer high tunnel at The OSU-OARDC in Wooster, OH, were seeded with ‘Outredgeous’ lettuce (*Lactuca sativa*) on 27 Oct. 2017, and 20 Feb. 2018. Each bed contained 14 rows (1.2 g seed/row) spaced 7 cm apart. One week after seeding, beds were assigned to one of four treatments (high day/high night - H/H, high day/ambient night - H/A, ambient day/high night - A/H, and ambient day/ambient night - A/A) arranged in a randomized complete-block design with five replications. “High” daytime temperatures were achieved by covering beds with vented 0.1524-mm thick polyethylene film, while “high” nighttime temperatures were achieved by covering beds with 50-AG Agribon fabric, both supported by standard low tunnel hoops. Thus, individual beds were either uncovered or covered with film during the day (approx. 08:00–17:00; all treatments) and either uncovered (A/A) or covered with film (H/A), fabric (A/H) or both materials (H/H) during the night. Canopy temperature was recorded every 15 minutes in all beds using HOBO U23-Pro Data Loggers throughout the seven weeks of each experimental run, with spontaneous readings of canopy light intensity (PAR) taken eight times over the experimental period. All vegetative tissue 1 cm above the soil line was removed from a 0.25-m² area/bed four weeks after seeding and a 0.18-m² area/bed seven weeks after seeding for measures of fresh and dry weight, total soluble solids (“Brix), leaf area and total anthocyanin concentration (Week 7 only). Samples were also included in sensory panel evaluation (discrimination tests based on color only) beginning in Spring 2018. The experiment will be repeated in Fall 2018 and Spring 2019. Differential day- and nighttime coverings resulted in treatment differences in...
Evaluation of Head Lettuce (*Lactuca sativa L.*) and Leafy Greens for Year-round Institution Markets in West Virginia (Poster Board #010)

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Lettuce (*Lactuca sativa L.*) is a leafy green vegetable that can be grown year-round in high tunnels in West Virginia. The summer growing season at higher elevation areas provides a suitable microclimate for warm season head lettuce production. The high tunnel also provides sufficient low temperature protection during the winter for extended season production. Like many U.S. states, there has been a tremendous expansion of high tunnel production of specialty crops within the last ten years. These same high tunnels provide tremendous capacity for wholesale marketing of lettuces and other leafy greens to institutional buyers such as schools and hospitals. From 2014–18 approximately 70 lettuce and other leafy green cultivars have been critically evaluated for stress tolerance, quality, shelf life, disease tolerance and marketable yield within high tunnels. From these evaluations, select cultivars for year-round production have been identified.

Specified Source(s) of Funding: SARE

Extending Tomato Production Season in South Texas Using Protected Structures (Poster Board #011)

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The Lower Rio Grande Valley in Texas is one of the most productive vegetable areas in the State. However, environmental conditions limit production to Spring and early Fall seasons when temperatures allow open field production. Furthermore, open field production is severely affected by strong winds, and high pressure of endemic/new insects and diseases. Protected structures such as high-tunnels offer an alternative to extend production season. High tunnels or hoop houses are relatively low investment structures that protect crops from the weather and pests. In order to determine the feasibility of production under high tunnels, two determinate and three indeterminate tomato cultivars including commercial available and Texas A&M developed hybrids were evaluated at two planting dates (October and November). Harvesting started in late December and was extended to the middle of June. October planting resulted in higher yields (56,104 kg/ha) and overall higher tomato total soluble solids (Brix 4.16%) as compared to November planting (36,869 kg/ha and Brix 3.76%, respectively). It is hypothesized that early seedling establishment when temperatures were higher contributed to observed yield and quality parameters differences between planting dates. Determinate cultivar tomato yields were higher as compared to indeterminate cultivars during first planting date but were lower during second planting. Observed differences between growing habit cultivars may have been in response to cold temperature resistance of indeterminate tomatoes, and to better light capture due to pruning during winter months. Finally, tomato taste panel was performed to determine consumer preference. Blind samples including a supermarket tomato control were offered to participants. Overall, high-tunnel tomatoes were preferred as compared to supermarket control. Texas A&M cultivar TAM “Hot Ty” had the highest levels of consumer rating in terms of flavor and color. In summary, our results indicate that winter production in high tunnels is feasible in South Texas resulting in good yields and quality.

Specified Source(s) of Funding: Texas A&M AgriLife Vegetable Seed Grant and Texas Department of Agriculture-Specialty Block Crop Grant

Yield Decrease with Delayed Fall Planting of Kale, Lettuce, and Spinach in High Tunnels (Poster Board #012)

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Fall-planted leafy greens are important crops for producers who harvest from high tunnels in late fall and winter. A survey of Indiana high tunnel producers identified planting schedules as an area in which more information is needed. We conducted trials to quantify the effect of planting date on yield of kale (*Brassica oleracea* var. *acephala* DC), lettuce (*Lactuca sativa*L.), and spinach (*Spinacia oleracea*L.) grown in soil in unheated high tunnels at Wanatah, IN. ‘Darkibor’ kale was transplanted and ‘Gazelle’ spinach was seeded in tunnels on six dates at two-week intervals starting 30 Aug. and ending 11 Nov. 2016. ‘Sulanova Red’ and ‘Green Reef’ lettuce were transplanted in tunnels on 30 Aug., 15 Sept., and 14 Oct. Each tunnel was 914 x 1463 m and had three replications of each planting date for each crop. Kale leaves with blades at least 20 cm long were harvested approximately biweekly from 27 Sept. through 14 Mar. 2017. Cumulative

An asterisk (*) following a name indicates the presenting author.
Organic Sweetpotato Slip Yield and Quality from a Central United States High Tunnel System (Poster Board #013)

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Sweetpotatoes (*Ipomoea batatas*) are nutritious, easily stored and well-adapted to fit large or small organic farming operations. This widely consumed root crop is propagated through use of cuttings, known as slips, which are grown primarily in the southeastern United States (U.S.). Consequently, growers in the central U.S. have limited control of and access to local planting material. Production of organic slips in high tunnels could be a profitable enterprise for growers in the central U.S. that would allow them to diversify their operation and encourage the use of crop rotations in high tunnels. Our study evaluated the yield and performance of slips grown in high tunnels as compared to the open-field. Similar trials were conducted in 2017 at two research stations in Northeast and South Central Kansas. We utilized a randomized complete block design for all trials, with at least 4 replications per treatment. Slip beds of ‘Orleans’ sweetpotato were established in high tunnels (HT) and open-field (OF) under identical cultural methods and planting schedule. Seed roots were planted at three planting densities (45, 65, and 85 seed roots/m²) in both the HT and OF. Slips were harvested from HT and OF plots and transplanted to field plots to investigate the impact of slip origin (HT vs. OF) on root crop production. At both locations, marketable slip yields (slips/m²) from the first harvest were similar in HT and OF plots. There was also no change in slip yield from increasing planting densities. However, slips from the first harvest at the South Central location only, planted at 65 roots/m² were shorter, had greater stem diameter, and had more nodes per length of stem than the other planting densities. Slips grown in HT at the Northeast location were 12% less compact (slip dry wt/cm length) than their OF counterparts. Total marketable sweetpotato yield was not influenced by HT or OF treatments (1.7 and 2.1 ls/plant, respectively). Similarly, the number of marketable roots was not affected by the HT or OF treatments (3.4 and 3.8 roots/plant, respectively). More research is needed to evaluate the feasibility of sweetpotato slips grown in high tunnel systems and to determine recommendations for seed root planting densities. However, the results of this study suggest that organic sweetpotato slip production could add to diversity in high tunnel systems. Moreover, local slip production might further promote the adoption of an underutilized vegetable crop that can be grown throughout the region.

Specified Source(s) of Funding: USDA

Evaluation of Lettuce Cultivars for Hydroponic Culture (Poster Board #014)

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Lettuce (*Lactuca sativa* L.) is one of the major leafy and salad vegetables. A total of sixty-four lettuce cultivars with green or red leaves in 5 different subtypes (butterhead, crisphead, loose leaf, oakleaf, and romaine) were evaluated for hydroponic culture using the NFT (nutrient film technique) system. Two-week old rockwool-grown seedlings were anchored 6” apart on an NFT system and grown for AN additional 4 weeks with a nutrient solution containing 200 ppm N prepared with a 20–20–20 commercial fertilizer. The lettuce crops reached marketable size within 3–4 weeks of transplanting into the hydroponic system. Performance factors evaluated for each cultivar 4 weeks after transplanting included fresh and dry weights, plant size and shape, stem diameter and length, leaf tissue pH, nitrate (NO₂⁻), calcium (Ca²⁺), and sugar contents, and tendency for bolting, molding and leaf tip burns. The cultivars of Adriana, Four Seasons, and Red Cross in butterhead type; Simpson Elite, Green Star, Tropicana, Two Star, Red Sails, and New Red Fire in loose leaf type; 3Sx4203 in oak leaf type; Concept, Magenta, Muir, Nevada, Lettony, and Cherokee in crisphead type; Parris...
Poster Presentations

Assessing Secondary Bud Fruitfulness of *Vitis vinifera* ‘Grenache’ and ‘Cabernet Sauvignon’ Vines Grown on the Texas High Plains: A Second Year Update (Poster Board #396)

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In 2017, there were approximately 1767 grape bearing hectares, and 394 wineries in the state of Texas. Within the state, the grape and wine industry had an overall economic impact of $13.1 billion. The vast majority of producing vineyards in Texas are located in regions which are subject to late spring frosts (which can severely reduce crop yield). Primary grape (*Vitis vinifera*) buds are considered less hardy, but more fruitful when compared to secondary buds. If Texas growers were more informed regarding grape cultivar secondary bud fruitfulness, secondary bud fruitfulness could possibly influence cultivar selection during vineyard planning. Therefore, objectives of this two growing season experiment were to compare growth and fruitfulness of shoots grown from primary and secondary buds of two *V. vinifera* cultivars on the Texas High Plains. *V. vinifera* ‘Cabernet Sauvignon’ and ‘Grenache’ vines on 110R rootstocks (trained to vertical shoot positioning with 2 cordon, 4 spur/cordon, and 2 buds/spur), and planted in a randomized complete-block design in 2006 were used for the experiment. Year one treatments included: primary bud remained (P), and following bud break (5–15 cm of new growth) primary buds removed (S). Year two treatments for ‘Grenache’ were repeated as in year one (PP, primary bud one and year two, and SS, secondary year one and year two). Growing season two treatments for ‘Cabernet Sauvignon’ included PP, primary bud one year, and secondary bud year two (PS), secondary bud year one, and primary bud year two (SP), and SS. Pruning weights, gas exchange data, and fruit quality data were collected each growing season. For each cultivar, pruning data indicate P, or PP shoots had greatest vegetative growth. Gas exchange, soluble solids (ºbrix), and mean berry weight data indicate few differences between treatments. However, PP ‘Cabernet Sauvignon’ and ‘Grenache’ vines had greatest cluster weights. For ‘Grenache’ vines, yield was reduced 30% in SS vines. In addition, compared to PP vines, yield of ‘Cabernet Sauvignon’ vines was reduced 45, 55, and 66% for PS, SS, and SP vines, respectively. Future research will look to determine additional cultivar differences, vine maturity response, and economic assessments.

Specified Source(s) of Funding: State of Texas Viticulture and Enology Funding

Characterization of Leaf Trichome Features for Their Potential Role in Resistance to Foliar Phylloxera in Cold Hardy Hybrid Grapes (Poster Board #397)

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Phylloxera has devastated the roots of wine grapes in Europe since the 19th century. Major measures to control this pest include grafting European wine grape variety, *Vitis vinifera*, onto resistant American rootstocks and hybrid breeding. However, many hybrids such as ‘Frontenac’ are susceptible to the leaf-galling form of phylloxera. Limited studies have investigated foliar phylloxera, including its genetic resistance and resistance mechanisms. Antibiosis, antixenosis, and tolerance have been the classical resistance mechanisms that a plant uses to combat an insect pest. This study investigates the role of leaf trichome features (the presence, density, and type of hair on leaf) in resistance to foliar phylloxera, as a potential morphological antixenosis/non-preference mechanism. Two advanced hybrid grape breeding lines, MN1264 and MN1246, and a resulting F1 population, GE1025 (N = 125), are examined on a 0–5 scale for trichome density on leaf blade and vein of the adaxial and abaxial sides of the leaf, as well as on leaf edge and petiole. The type of trichome is also examined: ribbon, simple, or glandular. This population has previously been evaluated for leaf phylloxera severity and sequenced using genotype-by-sequencing
with a major resistance QTL found on linkage group 14 (LG14). Preliminary results show that vein trichome density and petiole trichome density differ significantly between MN1264 and MN1246, compared with that of ‘Frontenac’ (susceptible) and ‘Louise Swenson’ (resistant) where vein, leaf, edge, and petiole trichome density differ significantly. Vein and petiole trichome type differ between MN1264 and MN1246, whereas vein, edge, and petiole trichome type differ between ‘Frontenac’ and ‘Louise Swenson’. Trichome density and type variation do exist in GE1025. The age and the side of the leaf measured might also play a role in contributing to trichome density differences. With these preliminary pieces of information, the population of GE1025 is under the process to be characterized for leaf trichome features, the relationship of which will be analyzed with foliar phylloxera severity (phenotypic correlation and coincidence of QTL). The significance of this study is to 1) develop a protocol to characterize leaf trichome in hybrid grape populations and 2) shed light on the underlying mechanisms of genetic resistance to phylloxera, whether leaf trichome plays a role, as high-resolution genetic mapping for resistance on LG14 is underway.

Specified Source(s) of Funding: Minnesota Department of Agriculture

Defining Water Stress Thresholds for ‘Edelweiss’ Grapevines (Poster Board #398)

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Irrigation is an important tool to increase grapevine vigor and fruit yield across the midwest United States. However, with enhanced pressure on water resources, vineyards are soon likely to experience water restrictions. Growers will need relevant information about grapevine water levels in order to efficiently irrigate their vineyards. This research focused on defining water stress thresholds for ‘Edelweiss’ (Minnesota 78 × Ontario) grapevines using midday leaf water potential ($\Psi_{md}$) and high resolution thermal infrared images from two different thermal sensors. Potted grapevines were subjected to a range of water stress treatments to evaluate water content levels (Control—fully irrigated and 2–14 days of water being withheld). After the 14-day water withholding period, thermal images were taken of the vines using an expensive Flir S62 camera and an inexpensive Flir C2 camera. Immediately following, a mature fully-expanded leaf was excised from the plant and tested for $\Psi_{md}$. Fully irrigated and 14-day dry vines exhibited a $\Psi_{md}$ of -8.7 bars and -13.3 bars, respectively. The grapevines exhibited a mild, moderate and severe water stress level at 8, 10 and 12 days-dry, respectively ($\Psi_{md}$ of -12 bars, -12.5 bars and -13 bars). The Crop Water Stress Index (CWSI) more accurately predicted $\Psi_{md}$ when using leaf temperature data collected by the inexpensive Flir C2 thermal camera ($P = 0.016$). The CWSI has been shown to be a good indicator of vine water status in more arid growing regions, but has not been well documented in humid climates. The CWSI calculated from the Flir

C2 temperature data had moderate correlations to $\Psi_{md}$ ($r^2 = 0.511$). Our results document the thresholds for mild, moderate and severe water stress levels for greenhouse grown potted ‘Edelweiss’ grapevines. Additional research and refinement is necessary in order to use the CWSI to accurately predict $\Psi_{md}$ in humid growing regions.

Cultivar Evaluation of Strawberries in Mississippi (Poster Board #399)

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Strawberry (Fragaria × ananassa) is a high value crop in the United States. Fresh strawberries are one of the most popular items at local markets. However, strawberry production in Mississippi is relatively small, and the high demand of strawberries in Mississippi are mainly supplied from other states. The objective of this study is to evaluate plant growth and berry yield of five June bearing cultivars (‘Chandler’, ‘Allstar’, ‘Earlyglow’, ‘Jewel’, and ‘Rutgers Scarlet’) and two day neutral cultivars (‘Evie 2’ and ‘Seascape’). Bare root liners of strawberry were transplanted into 2-gal containers in Feb. 2017 using pine bark: peat most: perlite in a volume ratio of 4:3:1 as growing substrate. Strawberry liners were fertilized with a slow release fertilizer Osmocote plus (15–9–12) at a rate of 20 g per container or with an organic fertilizer (5–3–4) at a rate of 60 g per container. All strawberry plants were grown outdoors on a nursery pad at Mississippi State University and irrigated as needed through drip irrigation. As for vegetative growth, there was no significant difference among strawberry cultivars in shoot or total plant dry weight. ‘Earlyglow’ produced the highest number of runner per plant (10.1 runners per plant), comparable to ‘Allstar’ (7.2 runners per plant), ‘Chandler’ (8.1 runners per plant), ‘Jewel’ (7.2 runners per plant), or ‘Seascape’ (6.0 runners per plant), higher than ‘Evie 2’ (4.4 runners per plant). As for reproductive growth, the two day neutral cultivars ‘Evie 2’ and ‘Seascape’ produced higher yield per plant than any tested June bearing cultivar, 165.7 g and 121.1 g berry per plant, respectively. ‘Chandler’ and ‘Evie 2’ produced the largest strawberry in terms of single berry weight, averaged 12.46 g and 13.16 g per berry, respectively, with ‘Earlyglow’ producing the smallest berry averaged 4.9 g per berry. The slow-release fertilizer Osmocote resulted in higher dry weights (root, shoot and total plant), SPAD reading, number of runner per plant, yield per plant, and single berry weight than organic fertilizer. This may have resulted from the slow nutrient releasing rate of the organic fertilizer, which did not satisfy fast growing habit of strawberries.

Yield Benefits of Recruiting Wild Pollinators in a Strawberry Agroecosystem (Poster Board #400)

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Around 75% of global food crops benefit to some degree from animal pollination, especially many fruit crops. Given emerg-
Evaluation of Selected Preplant Herbicides for the Enhancement of Strawberry Production Practices in Central Alabama (Poster Board #401)

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Sustainable production of strawberries (Fragaria xananassa) is challenged in Alabama due partly to the relatively restricted arsenal of effective chemistries for pest control. The objective of this study was to evaluate the effectiveness of pre-plant herbicides (four labeled for use and one not labeled for use) in strawberry production in order to develop recommendation for growers. A study was established at the Chilton Research and Extension Center (CREC) in Clanton, AL, on a fine sandy loam. Planting rows were prepared and herbicide treatments applied on 4 Oct. 2016. Rows were set on 1.8 m centers. Black plastic and drip irrigation were installed. Plants were set in double rows within a plot (0.9 m × 6 m) at a spacing of 35 cm. Preplant herbicides applied were bicyclopyrone (not labeled for use in strawberries) at a rate of (123 g·ha⁻¹), Blazer Ultra (0.3 L·ha⁻¹), Devrinol (1.5 L·ha⁻¹), Sinbar (17 L·ha⁻¹), and Spartan 4F (0.5 L·ha⁻¹). An untreated control plots were included. Plugs of ‘Camarosa’ strawberry plants were planted on 17 Oct. 2017. Treatments were planted according to a randomized complete block design with four replications. An analysis of variance was performed on all responses using PROC GLIMMIX in SAS version 9.4 (SAS Institute, Cary, NC). Early and total season marketable yield per plot and individual berry weight were analyzed using the normal probability distribution. Percent weed cover of plots treated with Devrinol (18 %) was similar to the untreated control. Bicyclopyrone (12 %), Spartan 4F (10.5%) and Sinbar (9.7 %) were similar in weed cover but had a lower percentage of weeds than all other treatments. Early season yields were highest in plots treated with Sinbar (941 g/plot). Other herbicide treatments produced early season yields similar to the untreated control. Total season yield of Sinbar (1126 g/plot) was similar to Spartan 4F (986 g/plot), Devrinol (1,041 g/plot), and Blazer Ultra (1,053 g/plot). Plants treated with Sinbar produced total season yields that were higher than the untreated control plots (872 g/plot). Individual berry weight from plots treated with Sinbar were numerically higher than all other treatments but there were no significant differences found among treatments. Cull weight of plots treated with Sinbar (353 g/plot) differed significantly from those treated with Devrinol (270 g/plot) and bicyclopyrone (216 g/plot) but similar to all other herbicide treatments and the untreated control. Total season cull weight was similar among all treatments with the exception of bicyclopyrone, which was statistically lower than all other treatments. Bicyclopyrone was also effective in controlling weeds; however, it is not labeled for use in strawberries and strawberry plants in plots treated with bicyclopyrone were stunted and chlorotic. Sinbar and Spartan 4F were among the most effective in controlling weeds. Sinbar was effective in encouraging the production of the highest yields during the early and late seasons.

An asterisk (*) following a name indicates the presenting author.

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Undergraduate Student (Poster)

Relating Harvest Date, Ground Color, and Preconditioning Treatments to Likelihood of Physiological Storage Disorder Development and Loss of Fruit Quality in ‘Honeycrisp’

(Poster Board #353)

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New apple cultivars like ‘Gala’ and ‘Honeycrisp’ continue to dominate the market in terms of demand and cost per pound. According to a National Retail Report conducted by the USDA, market price for ‘Honeycrisp’ apples were $3.11 per pound in March 2017. In March 2018, ‘Honeycrisp’ continued to have the highest market price of any variety surveyed at $2.39 per pound, 50% more expensive than runner-up ‘Fuji’. Farmers nationwide are devoting more acreage to ‘Honeycrisp’ and still struggling to meet demand, making it more important than ever for farmers to know when to pick and how to store in order to maximize yield and reduce loss. ‘Honeycrisp’ apples are harvested early and susceptible to several physiological storage disorders such as bitter pit, further increasing the necessitated skill for the venture of growing ‘Honeycrisp’. This is particularly critical in hot climates where red color development is difficult. The goal of this study was to test the relationship between harvest date, preconditioning, and both external and internal maturity markers at harvest on fruit quality and storage disorders in ‘Honeycrisp’ apples. ‘Honeycrisp’ apples were harvested from the same orchard in Adams County, Pennsylvania in August 2017. They were put into subgroups based on ground color at harvest for subgroup analysis to test the effect of preconditioning treatments of 0, 2, and 4 days. Apples were measured using common maturity indices after harvest and evaluated for physiological disorder after two months of refrigerated storage; the same measurements were taken again after five months of storage. As hypothesized, results indicated that harvest date had a larger impact on resulting fruit quality and physiological disorders than ground color at harvest or preconditioning treatments.

Specified Source(s) of Funding: State Horticultural Association of Pennsylvania (SHAP)

Growth and Yield of Zucchini Fruit under Hydroponic Culture Condition

(Poster Board #354)

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Recently, yield of zucchini increases rapidly in Japan. The major production method is in out-field, however as the cultivation term is relatively short, alternative cultivation methods are needed. Soilless culture for zucchini was studies recently, but not hydroponic culture. We investigate the possibility of this technique for zucchini fruit production. We grew zucchini (Cucurbita pepo L. cv. Greenport 2 go) plants in a glass greenhouse from March to June in 2016 and 2017. Two of seedlings were grown in each container that contained 3 different concentration of hydroponic solution. At least 8 plants were grown for each treatment. We investigated the timing of cultivation, fruit size and fresh weight (yield). Under three different conditions of hydroponic solution, the concentration at EC 1.2 had the highest yield, however, fruit yield tended to decrease at the end of cultivation due to the quality of flowers were decreased. These tendencies were observed on both experimental years. We further have to develop the technique to improve the quality and quantities of zucchini yields.

Effects of Different Media Formulations on Orchid Seed Germination

(Poster Board #356)

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Techniques for orchid seed germination are important for orchid breeding and conservation efforts. Orchid seeds do not contain an adequate endosperm food source and instead derive their nutrients through a symbiotic relationship with mycorrhizal fungi. Orchid seeds cannot germinate without this symbiotic relationship. Tissue culture forms the basis of commercial orchid seed propagation. Using tissue culture and media prepared to provide proper nutrition, orchid seeds can be germinated without the mycorrhizal fungi. The objectives of this research were to measure the germination rate and protocorm and seedling development of different orchid genera using 15 different media formulations supplemented with either coconut water or pineapple powder. The media evaluated included five different formulas of Vacin and Went, Knudson C, and PhytoTech Orchid Seed Sowing Media (P723). All media formulations were supplemented with 10% and 20% coconut water and 10% and 20% pineapple powder. Each media was also evaluated without the coconut water or pineapple powder. Orchid seed sowing was conducted aseptically using green seed pods of Dendrobium, Grammatophyllum, and Cymbidium species. The results compared the germination and development of the different orchid genera on the different media. This research is of significance for improving the techniques for orchid seed germination.

An asterisk (*) following a name indicates the presenting author.
Irrigation systems are designed to maximize crop productivity and optimize uniform water application. The amount of water applied is usually determined by empirical methods, which are based on timers instead of the actual crop requirements. Several technologies have recently been developed looking for alternative methods to improve water management efficiency based on weather and soil sensing methods. One of the most relevant advances are the capacitance sensors, offering a great potential to estimate soil volumetric water content (VWC) and electrical conductivity. We conducted a laboratory study to evaluate the accuracy of data collected from several commercial capacitance sensors and establish a calibration equation for different soil types. Tested treatments were five sandy soils (Pineda, Riviera, Astatula, Candler and Immokalee) divided in two depths (0–30 and 30–60 cm) representing the majority of Florida soils used for citrus production. We also tested a soilless substrate (peat:perlite 80%:20% v/v). Each sample was oven dried and placed into 5-gal buckets, with three replications. Readings were taken using thirteen capacitance sensors from different manufacturers [CS650, CS616, CS655 (Campbell Scientific), GS3, 10HS, 5TE, GS1 (Decagon Devices), TDT-ACC-SEN-SDI, TDR315, TDR315S, TDR135L (Acclima) and Hydraprobe (Stevens)] connected to a CR1000X datalogger (Campbell Scientific). The bulk density of each soil was determined by following ASTM D7263 standards and the specific gravity according to ASTM D854 standards, defining the reference for further calculations related to VWC. Known amounts of water were added incrementally to obtain a broad range of VWC values until reaching the saturation point; the soil was dumped into a larger container, thoroughly mixed and put back in the original containers. The measurements were performed by inserting the sensor in the middle of the sampling container. Small 450-cm sand samples were taken and dried in an oven at 75 °C for 48 h to determine the gravimetric water content. Gravimetric values were multiplied by the bulk density to determine the VWC used to obtain the soil-specific calibration equations and compare the sensor accuracy. Results indicated that factory-supplied calibration equations performed well for some sensors in sandy soils, especially 5TE, TDT-ACC-SEN-SDI and GS1, with higher correlation between the sensor readings and the determined VWC; that was not the case for 10HS, GS3 and Hydraprobe. The sensor readings were measured successfully in increasing VWC values, establishing soil-specific calibration equations for Florida soils. Those results allow the improvement of sensor reading accuracy, optimizing irrigation scheduling and water management in Florida citrus production areas.

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First found in 1894 by Marcus E. Jones, *Penstemon × jonesii* Pennell was later described as a species in 1920 by Francis W. Pennell. In 1967, Frank S. Crosswhite hypothesized that it is a natural hybrid of *P. laevis* and *P. eatonii*. It is now widely accepted as the putative natural hybrid of those two species. It has been identified in relatively concentrated areas in Southwestern Utah. This taxon has long been recognized as a candidate for horticultural selections due to its beautiful “Tyrann rose”, “amaranth purple”, or red-purple to maroon colored blooms (Neese). Understanding the phylogenetic relationships of this taxon is valuable to assist in the development of cultivars derived from *P. × jonesii* for urban landscapes. In conflict with the claim of the natural hybridization of the two aforementioned *Penstemon* species, *P. × jonesii* exhibits phenotypic incongruencies with controlled experimental crosses of *P. eatonii × P. laevis*, which have bloomed in our greenhouse. Using ten *Penstemon* microsatellite markers we have been examining the allelic variations between *P. × jonesii*, *P. eatonii*, and *P. laevis*. Our preliminary results suggest that *P. × jonesii* is not a first generation (F1) hybrid of *P. eatonii* and *P. laevis*. These early SSR data suggest that *P. × jonesii* is more closely related to *P. eatonii*, than *P. laevis*. We now have reciprocal hybrid plants of the two parental species (*P. eatonii* and *P. laevis*); as well as hybrid plants growing where *P. × jonesii* was the male parent in crosses with *P. eatonii*. All of our preliminary data support our working hypothesis that *P. × jonesii* is more closely related to *P. eatonii* than *P. laevis*.

**Specified Source(s) of Funding:** Brigham Young University  
Department of Plant and Wildlife Sciences

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**Relative Salt Tolerance of Ornamental Grasses and Grass-like Plants**  
**(Poster Board #360)**

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Youping Sun  
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Ornamental grasses are popular in urban landscapes in Utah and the Intermountain West, one of the driest and fastest growing regions in the United States (U.S.). An estimated $158 million worth of ornamental grasses are sold annually in U.S. Alternative water sources such as graywater and reclaimed municipal water are becoming important resources for landscape irrigation. These water sources are known to carry relatively high levels of salts, which negatively affect plant growth and development. Therefore, understanding the salinity tolerance of different ornamental grasses can be beneficial for preventing salt damage to ornamental plants while maintaining appealing landscapes. Five ornamental grass species (*Bouteloua gracilis* (blue grama), *Chasmanthium latifolium* (inland sea oats), *Leymus arenarius* ‘Blue Dune’ (sand ryegrass), *Muhlenbergia capillaris* (pink muhlygrass), and *Pennisetum alopecuroides* ‘Foxtrot’ (foxtail fountain grass)) and two ornamental grass-like species (*Carex vulpinoida* (fox sedge) and *Juncus effuses* (common rush)) were assessed for salinity tolerance in a greenhouse. Plants were irrigated weekly with a nutrient solution at an electrical conductivity (EC) of 1.2 dS·m⁻¹ (control) or saline solution at EC of 5.0 dS·m⁻¹ (EC 5) or 10.0 dS·m⁻¹ (EC 10) for eight weeks. At nine weeks after the initiation of treatment, in EC 5, *L. arenarius*, *M. capillaris* and *P. alopecuroides* had no foliar damage with a visual score of 5 (0: dead; 5: excellent), while *J. effuses*, *B. gracilis*, *C. latifolium*, and *C. vulpinoida* showed some foliar damage with an averaged visual score of 4.5, 3.8, 3.7, and 3.0, respectively. In EC 10, *L. arenarius*, *M. capillaris*, *P. alopecuroides*, *J. effuses*, and *B. gracilis* exhibited no or minimum foliar damage with an averaged visual score of 4 or greater. However, *C. latifolium* and *C. vulpinoida* had slight foliar damage with averaged visual scores of 3. Compared to control, shoot dry weight (DW) of *C. vulpinoida* in both EC 5 and EC 10 was decreased by 16%, whereas shoot DW was reduced by 24% and 54% for *P. alopecuroides* in EC 5 and EC 10, respectively. The reduction in shoot DW in other species was no significant. This experiment is still underway to select the most salt tolerant ornamental grasses for aesthetically appealing landscapes that is irrigated with alternative waters.

**Specified Source(s) of Funding:** New Faculty Start-up Funding from Plants, Soils & Climate, Center for Water-Efficient Landscaping, Utah Agriculture Experiment Station, and The Office of Research and Graduate Studies, Utah State University

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**Thursday, August 2, 2018**

**Consumer Horticulture and Master Gardeners (Poster)**

**Master Floral Designer: A New MSU Extension Certificate Program**  
**(Poster Board #080)**

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A series of two-hour, floral design workshops was developed beginning 2015 at the MSU Coastal Research and Extension Center, Biloxi, MS. Workshop participants were surveyed from Oct. 2015 to June 2016. Respondents agreed that they desired to achieve a certificate in floral design (77%), while 64% strongly agreed (n = 106). A Master Floral Designer (MFD) category was planned and a pilot program was implemented in Jan. 2017. Similar to the Master Gardener program in scope, the program consists of 42 hours studio (lecture, demonstration, and hands-on practice) and a volunteer segment requiring 40 hours of work. To date, 17 people have participated in the studio segment and seven have completed the volunteer segment.
Research Based Infographics Convey and Build Awareness of Plant Benefits (*Poster Board #081)

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Debbie Hamrick
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Jennifer Gray
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Jill Calabro
AmericanHort/HRI, Washington, DC, USA

The Economic Committee of the National Initiative for Consumer Horticulture worked throughout 2017 to Apr. 2018 to operationalize a peer-reviewed publication by Hall and Dickson (2011). Their publication, *Economic, Environmental, and Health/Well-Being Benefits Associated with Green Industry Products and Services: A Review* contained citations of 134 studies that extolled the benefits of plants. In order to gain widespread adoption and use of plant benefits, the committee developed the first Infographic entitled *The Power of Plants: Enriching Lives, Creating Jobs, Building Wealth, Saving Money* which was released in 2017. Given the tremendous number of plant benefits, the committee was encouraged to create four additional infographics in a series under the banner #PlantsDoThat Inside Where We Live, Learn, Heal, and Work. The free infographics are available on the NICH website for use by any company or enterprise to endorse the benefits of plants using research-based information. The goal is to facilitate the objectives of NICH to educate the public on the multiple benefits of plants and encourage more purchase and enjoyment of plants by the American public.

Taking the Trial to the People: Citizen Science Project for Tennessee Vegetable Gardeners (*Poster Board #082)

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Edible gardening is an important part of consumer horticulture because of its potential to improve human well-being through physical activity and food provision. Additionally, recent increases in food gardening participation have included younger generations and first-time gardeners across the rural to urban continuum. With participation in food gardening estimated to be one-third of households nationwide, the stakeholder audience is both wide and diverse. The selection of crops and care of home gardens are frequent questions for Extension educators. Questions related to variety selection for the home garden are particularly challenging to answer due to a lack of geographically pertinent data. The time and expense of managing cultivar trials, reduced funding for consumer horticulture research, and the wide range of growing conditions across the highly varied geographical regions of Tennessee create significant hurdles for researchers trying to answer the question, “which variety should I grow in my home garden?” A collaborative approach between researchers and citizens may hold the key to addressing these challenges. In 2017, a home garden vegetable trial program was established to evaluate home vegetable crops and cultivars across the state. This trial took a citizen scientist approach and provided home gardeners the opportunity to evaluate variety performance at their own sites across the gardening environments represented in Tennessee. Participants were allowed to choose from a selection of paired variety comparisons in a number of different vegetable categories. Seeds and instructions were mailed to participants who then grew the trials and returned evaluation data on key characteristics such as germination, yield, appearance, and flavor. In the pilot year, participation was limited to 15 counties. From these 15 counties, 47 citizen scientists put out a total of 247 trials. In addition to producing previously unavailable information on variety performance in Tennessee, this project has provided an opportunity for Extension to directly engage citizens; increasing knowledge of vegetable gardening, encouraging physical activity and healthy eating, and expanding knowledge of the scientific process within the stakeholder audience.

Gardening and Art Activities: Comparing Health Outcomes in a Clinical Study of Healthy Women (*Poster Board #083)

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Health broadly encompasses well-being in physical, mental and social areas. Much of the extant literature in the area of horticultural therapy and people-plant interactions lacks experimental comparisons between gardening and other allied therapeutic modalities for any population. In this clinical study an active, concurrent control group was used to compare relative health outcomes associated with engaging in gardening and art activities. Treatment-based outcomes for perceived stress, mood disturbance, depression symptomatology, anxiety, quality of life, social satisfaction, cardiovascular and physical health factors were investigated using a battery of self-reported psychometric assessments and cardiovascular monitoring for a population of healthy women randomly assigned to gardening or art groups. Appraisal of the results from the four-week interventions provides evidence that tests treatment effect hypotheses associated within and between the gardening and art therapeutic modalities.

Specified Source(s) of Funding: Horticultural Research Institute; Gene and Barbara Batson Endowed Nursery Fund; Florida Nursery, Growers and Landscape Association; and Department of Environmental Horticulture

Evaluation of Alternatives to Glyphosate for Organic Gardening Systems (*Poster Board #084)

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Interest in organic vegetable gardening has increased among homeowners in recent years. A growing number of people are
searching for alternatives to glyphosate for weed suppression and control for establishing and maintaining vegetable gardens. In this study, weed control treatments were evaluated as well as the number of follow-up treatment applications needed for garden plot establishment. This study was conducted twice and each study lasted 131 days during the summer growing season of 2016 and 2017 in Richmond, KY. Treatments included a control and two application periods (fall and spring) of glyphosate, vinegar [5% acetic acid (AA)], 20% horticulture grade vinegar (20% AA), and 30% horticulture grade vinegar (30% AA). Following the treatments, each plot was evaluated using a quality rating (1–9 scale, 1 = 100% of the plot is dead and 9 = 100% of the plot is alive with weeds). After the initial treatment applications, quality ratings of the 5%, 20%, and 30% AA declined quickly to a rating of one within three days while the glyphosate required seven days to reach a rating of one. Treatments were reapplied to subplots in the spring when a plot received a quality rating of five (approximately 50% of the plot had regrown with weeds). Glyphosate performed the best requiring 71–80.8 days to reach 50% regrowth with both a fall and spring application of glyphosate (average of 78 days) achieving better results than a spring application alone (average of 73.8 days). Control plots had the least number of days to full regrowth after the spring treatment application with 96 (2016) and 79.7 (2017) days after treatment (DAT) compared with glyphosate which took more than 105 DAT for full regrowth in 2017 and did not fully regrow in 2016 within the 131 days of the study. Five (2016) and nine (2017) retreatment applications to subplots were required in the 5% AA plots while glyphosate only required one retreatment application each year. The 20% and 30% AA both required approximately three (2016) and four (2017) retreatments. In this study, glyphosate has shown to be the more effective weed control method for vegetable gardens. In cucurbit gardens with reduced soil exposure, both 20% and 30% AA are viable alternatives to glyphosate.

**Genetics and Germplasm 1 (Poster)**

**Two Unique Apple Hybrid Populations Segregating for Many Phenotypes of Horticultural Importance** *(Poster Board #264)*

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Khalil Jahed
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With a number of genomics approaches now being able to be applied to perennial tree fruits relatively easily and inexpensively, the availability of segregating hybrid populations is often a constraint. We have two hybrid populations, each derived from crosses of a large-fruited genotype (‘20 Ounce’ and ‘Edward VII’) and a very small-fruited crabapple genotype (‘Prairie Fire’). These populations have a much wider genetic basis than commonly found in apple breeding populations since the parents represent different *Malus* species. Each population is comprised of approximately 100 fruiting seedlings. While our primary purpose is to use these populations to investigate fruit size regulation, the populations are segregating for many other traits of potential interest. Some of these include tree characteristics such as branch angle, leaf color, flower color, and flower number per tree and per cluster. Wide variation in fruit characteristics is also evident including fruit size, fruit skin, and flesh color, soluble solids concentration, fruit acidity, maturity time, fruit abscission, and fruit surface characteristics. There is also likely segregation for pest and disease susceptibility. We are in the process of genotyping all the seedlings in both populations, however phenotyping has been limited to focusing on fruit size. We are inviting collaborators to phenotype these populations for traits of interest and we are willing to share genotype information.

**RNA-Seq Analyses of a Late Maturing Somatic Mutation Identify a Co-expressed Gene-network Module Associated with Fruit Development in Apple** *(Poster Board #265)*

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In tree fruit, somatic mutations may alter fruit color, size, shape, and maturation date. ‘Autumn Gala’ is a somatic mutation from a widely grown apple cultivar ‘Gala’. The fruit of ‘Autumn Gala’ distinguish from those of ‘Gala’ by a 4-week delayed maturation date and a longer shelf life. Fruit maturation is a genetically programmed event involving numerous biochemical, physiological, and structural alterations. To understand the molecular mechanisms underlying the remarkable fruit maturation delay and shelf life extension, RNA-sequencing (RNA-Seq) analyses were conducted at various stages during fruit development and postharvest storage from ‘Gala’ and ‘Autumn Gala’. A total of 102 RNA-Seq libraries, including 48 (24x2) for ‘Gala’ and 54 (27x2) for ‘Autumn Gala’ were sequenced using next-generation genome sequencer illumina HiSeq 2500. RNA-Seq data analysis was conducted using CLC Genomics Workbench and the software package R. To identify casual factors responsible for late maturation, gene expression profiles throughout the developmental stages were analyzed. In total 9368 differentially expressed genes (DEGs) were identified between ‘Gala’ and ‘Autumn Gala’ at each developmental stages and between the adjacent stages. A weighted gene co-expression network analysis (WGCNA) of the DEGs uncovered a network module of 57 genes highly correlated (*r* = 0.98, *P* = 4e-21) with the suppressed expression in ‘Autumn Gala’. Among the 57 genes, 49 were located within a 2.7Mb region on chromosome 6. Further analysis is underway to identify if there are any genomic structural changes in this region that might have impacted on fruit maturation.

An asterisk (*) following a name indicates the presenting author.

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Identification and Characterization of a Strong Candidate Gene for Weeping Growth Habit in Malus (Poster Board #266)

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Downward branches characterize the weeping growth habit. In Malus, the weeping tree form is common in crabapples, such as ‘Cheal’s Weeping’ and ‘Red Jade’, which are highly desired for ornamental use. Although most apple cultivars grow their branches upward with certain angles, a branch bending down practice is recommended in several modern orchard training systems, such as Solaxe and Tall Spindle. Term ‘weeping’ here distinguishes from the same term used for ‘ideotype IV’ that described the growth habit and fruit bearing type represented by apple cultivars ‘Granny Smith’ and ‘Rome Beauty’, where the weeping-like trait is caused by the bending of branches due to fruit bearing at tips. To determine the genetic cause of weeping growth habit in Malus, a pooled genome sequencing-based approach was taken using an F1 population segregating for the weeping trait. Through a detailed analysis of segregation types of DNA variants, four genomic regions were revealed of a strong candidate gene MDP0000254069 (MD13G1122400) encoding a LAZY1-like protein was identified, designated MdLASY1. Apple transgenic lines under-expressing the MdLASY1 grow leaves downward while those over-expressing the gene grow leaves with normal angles at young stage. Currently, an extensive effort to characterize MdLASY1 is underway.

Specified Source(s) of Funding: NSF-Plant Genome Research Program grant (IOS-1339211)

Understanding Armillaria Root Rot Tolerance/Resistance in Prunus (Poster Board #267)

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Armillaria root rot (ARR) disease is affecting stone fruit and nut crops throughout the U.S. and is the greatest threat to peach and cherry orchard sustainability in the southeastern U.S. and the Great Lakes Region, respectively. ARR has become a serious and widespread problem in the major tart and sweet cherry production regions of Michigan and is responsible for tens of millions of dollars in losses in historic peach production regions of Georgia and South Carolina. The causal soil-borne fungi, Armillaria spp., infect the root system, typically killing trees when they are reaching their maximum productivity, making orchards unprofitable, and the infected land unsuitable for continued stone fruit production. At present, there is no environmentally safe, clean management strategy for ARR in Prunus spp. tree fruits, and the few management options that are available are only marginally effective at best. The longer peach and cherry trees are cultivated at a single location, the more fungal inoculum in the form of infested root pieces builds up in the soil. Therefore, replant sites with a history of ARR are considered economically unfeasible for continued peach and cherry cultivation. At such locations, it is not uncommon for trees of only 3 and 4 years of age to succumb to ARR. Therefore, the most economical and potentially effective solution to combat Armillaria is through use of genetic resistance. To understand ARR tolerance/resistance in Prunus and uncover potential sources of tolerance/resistance that could be used in rootstock breeding, we used in vitro infection to screen 81 Prunus spp. wild accessions from the National Clonal Germplasm Repository in Davis, CA. Preliminary results of the in vitro screen and root microscopy confirm tolerance to A. mellea in a few P. cerasifera accessions. Implications for breeding new resistant rootstocks via introgression of resistance genes from wild relatives into stone fruit-compatible rootstocks will be presented.

Specified Source(s) of Funding: USDA-AMS-SCMP-2015 “Short and Long-Term Solutions for Armillaria Rot Rot in Prunus (ME#44165761)

Comparing Acetogenin Activity in Ripe Fruit and Twig of Pawpaw [Asimina Triloba (L.) Dunal] Varieties Using the Brine Shrimp Test (Poster Board #268)

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Pawpaw [Asimina triloba (L.) Dunal] is a tree fruit native to Eastern North America in its initial stages of commercial production...
in the United States. Annonaceous acetogenins are long chained fatty acids contained in pawpaw fruit and vegetative tissues, which display pesticidal and anti-tumor properties. Kentucky State University (KSU) is the site of the USDA Repository for pawpaw species, and germplasm evaluation and collection are program priorities. Fruit is a major biomass source for acetogenin extraction; however, it takes 5–8 years for a tree to mature and produce fruit. Comparing annonaceous acetogenin activities can possibly allow breeding programs to focus directly on breeding a desired level of acetogenin activity in pawpaw trees. In this study we aim to determine if there is a correlation between annonaceous acetogenin activity in varieties of ripe pawpaw fruits and twigs. Pawpaw fruit and twigs were collected from individual trees of pawpaw varieties and advanced selections (Sunflower, Hi 7-5, Hi 4-1, Susquehanna, and PA Golden) with known and unknown fruit acetogenin activity. 2.5 g of dried twig tissue were extracted with 25 mL of 95% ethanol and 10 g of frozen fruit pulp were extracted with 25 mL of 95% ethanol. Concentrated extract was transferred to vials to correspond to 5, 10, and 50 ppm concentrations for pulp extracts and vials containing 0, 1.0, 5.0, 10, and 15 ppm concentrations of twig extracts. There were replicates for each concentration. A brine shrimp test (BST) was used to compare mortality in both twig and pulp for each variety and they all showed varying degrees of mortality which indicate acetogenin activity in the varieties. Results suggest that twig extract activity can be used to identify pulp activity in pawpaw fruit of the same variety and high twig activity indicates high fruit activity.

Specified Source(s) of Funding: USDA Evans Allen Research

**Apomictic and Sexual Seed Reproduction in Aronia and Implications for Breeding and Commercial Fruit Cultivars (Poster Board #269)**

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Native to eastern regions in North America, the genus *Aronia* is a group of deciduous shrubs in the Rosaceae family, subtribe Pyrinae. The four commonly accepted species include *A. arbutifolia* (L.) Pers., red chokeberry; *A. melanocarpa* (Michx.) Elliott, black chokeberry; *A. prunifolia* (Marshall) Reheder, purple chokeberry; and *A. mitschurinii* (A.K. Skvortsov & Maitul), involving *A. melanocarpa × Sorbus aucuparia* hybridization. Very little has been accomplished with genetic improvement involving *A. arbutifolia* and *A. melanocarpa.*

Very little has been accomplished with genetic improvement involving *A. arbutifolia* and *A. melanocarpa.*

For experiment I, 20 *Aronia* accessions (five *A. melanocarpa* [2x], four *A. melanocarpa* [4x], three *A. prunifolia* [3x], four *A. prunifolia* [4x], three *A. arbutifolia* [4x], one *A. mitschurinii* [4x]) were used in this study. Intra-accession variability was evaluated by growing out progeny from an open-pollinated maternal accession and comparing Amplified Fragment Length Polymorphism (AFLP) profiles between the progeny and maternal accession. Diploid accessions produced a significant amount of genetic variation (0.6–0.8 Jaccard’s similarity coefficient) in progeny which was indicative of sexual reproduction. Seedlings from tetraploid accessions had very little genetic variation (0.90–0.98 Jaccard’s similarity coefficient) in comparison to their maternal accession. The very limited genetic variation observed in tetraploid progeny suggests that apomictic diplospory with one round of meiotic division is occurring. Triploid accessions appear to reproduce via sexual reproduction and apomictic diplospory. For experiment II, genetic similarities were determined for nine *A. mitschurinii* cultivars that are commonly used in commercial fruit production. All cultivars, except for ‘Nero’, were genetically identical, with ‘Nero’ producing a Jaccard’s similarity coefficient of 0.97. We propose that the same genotype has been renamed repeatedly by growers. Nero is likely a seedling of the primary clone in commerce, since it has a similarity coefficient that is equivalent to what we observed in tetraploid *Aronia* progeny.

**Preliminary Results of a Genotyping-by-Sequencing Diversity Study of Big-bracted Dogwood (Cornus spp.) Cultivars (Poster Board #270)**

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Big-bracted dogwoods (*Cornus spp.*) are small trees that are prized as ornamentals in managed landscapes because of their beautiful spring blooms with showy bracts, striking red fruits, and attractive fall color. Two of the most popular species are *C. florida* and *C. kousa.* *Cornus florida* is native to the eastern United States and blooms early in the spring before its leaves appear. *C. kousa,* from Asia, blooms later than *C. florida* and is more resistant to powdery mildew and dogwood anthracnose. Vigorous, disease-resistant hybrids between the two species can also be found in cultivation. A performance trial holding 96 different accessions of big-bracted dogwoods was established in 2016 at Rutgers University in New Jersey. In this study, we are using the genotype-by-sequencing (GBS) approach to discover single nucleotide polymorphisms (SNPs) within our *Cornus* ac-
cessions and use them to examine relationships, clonal identities, genetic diversity, and population structure. As a preliminary trial before including the entire collection, we focused on a subset of 48 accessions: 20 *C. floridana*, 20 *C. kousa*, and 8 interspecific hybrids. DNA was extracted from dormant flower buds using Qiagen DNeasy Plant Kit, and quality and concentration was quantified with a spectrophotometer. DNA was double digested with PstI-HF and MspI, barcoded, multiplexed, and sent to Genewiz labs for sequencing. The raw data will be analyzed with Stacks, JoinMap, and STRUCTURE. Results, including the number of high quality SNPs as well as indices of diversity and relationships between the preliminary subset of *Corus* cultivars, will be presented. These data will support a larger study and provide valuable insight into the genetic diversity and population structure of these important landscape plants, as well as guide future germplasm collection efforts for the development of improved cultivars.

**Cytogenetics and Genome Size Evolution in *Illicium* (Poster Board #271)**

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*Illicium* is an ancient genus and member of the earliest diverging angiosperms known as the ANA grade (Amborellales, Nymphaeales, and Austrobaileyales). These adaptable, broadleaf evergreen shrubs, including approximately 40 species distributed throughout Asia and North America, are valued for diverse culinary, medicinal, and ornamental applications. The study of cytogenetics of *Illicium* can clarify various discrepancies and further elucidate chromosome numbers, ploidy, and genome and genome size evolution in this basal angiosperm lineage and provide basic information to guide plant breeding and improvement programs. The objectives of this study were to use flow cytometry and traditional cytology to determine chromosome numbers, ploidy levels, and relative genome sizes of cultivated *Illicium*. Of the 29 taxa sampled, including approximately 11 species and one hybrid, 2C DNA contents ranged from 24.5 pg for *I. lanceolatum* to 27.9 pg for *I. aff. majus*. The genome sizes of *Illicium* species are considerably higher than other ANA grade lineages indicating that *Illicium* went through substantial genome expansion compared to sister lineages. The New World sect. *Cymbostemon* had a slightly lower mean 2C genome size of 25.1 pg compared to the Old World sect. *Illicium* at 25.9 pg, providing further support for recognizing these taxonomic sections. All taxa appeared to be diploid and 2n = 2x = 28 except for *I. floridanum* and *I. mexicanum* which were found to be 2n = 2x = 26, most likely resulting from diploid reduction following divergence into North America. The base chromosome number of x = 14 for most *Illicium* species suggests that *Illicium* are ancient paleotetraploids that underwent a whole genome duplication derived from an ancestral base of x = 7. Information on cytogenetics, coupled with phylogenetic analyses, identifies some limitations, but also considerable potential for the development of plant breeding and improvement programs with this genus.

**Chloroplast Sequence, Assembly, and Annotation of Six Penstemon Species**

(Poster Board #272)

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North American beardtongue (*Penstemon* Mitch.) species form a diverse group that occupies a wide variety of ecological habitats and niches. With approximately 270 species, the genus spans North America, from the Arctic to the tropics, and are organized into six monophyletic subgenera, *Dasanthera*, *Saccanthera*, *Cryptostemon*, *Dissecti*, *Habroanthus*, and *Penstemon*. Due to their diverse floral and vegetative traits, beardtongues have great horticultural value, and have been utilized in several breeding programs since the early 1800s. To assess genetic diversity of breeding stock, and to prioritize potential crosses in our breeding program, we sequenced representative species of each beard tongue subgenus, *Penstemon fruticosus* (*Dasanthera*), *P. rostriflorus* (*Saccanthera*), *P. personatus* (*Cryptostemon*), *P. dissectus* (*Dissecti*), *P. cyaneus* (*Habroanthus*), and *P. palmeri* (*Penstemon*), using the Illumina HiSeq platform (Illumina Inc., San Diego, CA). Our sequencing data, 2 × 250 pair-end reads, contained sufficient genome coverage to assemble and annotate the complete chloroplast genome (plastome) for each species. We evaluated the complete plastomes for SSRs and repetitive sequences using the programs MISA and REPuter. We also compared whole plastome Maximum Likelihood phylogeny to the *rbcL* gene phylogeny of 12 *Solanum* species, with *Solanum lycopersicum* as an outgroup. Plastome lengths varied between 152,598 base pairs (bp) and 152,739 bp for *P. rostriflorus* and *P. cyaneus* respectively. The number of SSRs identified in each plastome varied between 16 and 23 for each species. The SSR nucleotide composition and location also varied between species. Repetitive sequence length for each species were also highly variable between 25 bp and 147 bp, with one repeat of over 7000 bp in *P. rostriflorus*. All species had multiple palindromic and forward repeats except *P. cyaneus* and *P. palmeri*, which only had one and two forward repeats, respectively. While the phylogenetic topologies within the Plantaginaceae remained consistent, the relationships between the other species of the
Lamailes order were not consistent between the plastome phylogeny and rbcL phylogeny. The complete plastome sequences have improved our understanding of the phylogenetic relations of the beardtongue subgenera over commonly used single gene phylogenies. This will help us to predict breeding success of crosses between closely related species, as well as potentially break reproductive barriers of distantly related species by first making crosses with intermediate species.

**Analysis of Genetic Diversity of Piedmont Azalea by Genotyping-by-sequencing**
*(Poster Board #273)*

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Piedmont azalea (*Rhododendron canescens*) is the most common native azalea in the southeastern United States, ranging from Texas to North Carolina. It is of interest as a landscaping plant because of its adaptability, lace bug resistance, and early flowering. Piedmont azalea is one of the first native azalea species to bloom and could benefit early spring pollinators in urban landscapes. Information on the genetic diversity and population structure of Piedmont azalea would be useful for breeding and conservation biology. We used genotyping-by-sequencing (GBS) to examine 88 genotypes from Georgia and Florida. Bar-coded libraries of MspI/PstI-digested DNA samples were sequenced by Illumina NextSeq 500. Single nucleotide polymorphisms (SNPs) were identified using TASSEL and filtered at a minor allele frequency of 0.05. A total of 5186 SNPs were discovered by GBS, of which 1739 high quality SNPs were retained by TASSEL for further analysis. Since no reference genome was available for alignment, one of the genotypes from the population was selected to create a mock reference genome and all other genotypes were aligned to it. Analysis of population structure using STRUCTURE software showed that the Piedmont azalea genotypes could be grouped in three distinct populations based on delta K = 3. Principle component analysis corroborated the STRUCTURE results showing three different population clusters. A neighbor-joining tree was constructed based on the SNP data to determine genetic relationships of the Piedmont azalea genotypes. Information derived from GBS analysis will benefit the breeding of Piedmont azaleas for urban landscapes.

**Specified Source(s) of Funding:** Southern California Plumeria Society and Plumeria Society of America

**Cioa 2—Carrot Improvement for Organic Agriculture with Added Grower and Consumer Value** *(Poster Board #276)*

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Utilization of Carrot Cwrs for Carrot Pre-breeding in Bangladesh and Pakistan
(Poster Board #277)

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Carrot is a very widely grown vegetable that is not only a valuable cash crop, but also an excellent source of Vitamin A derived from the orange pigments familiar to consumers. Carrot production has historically been in cooler climates, but with the development of carrot cultivars for subtropical regions of Brazil in the last 40 years, carrot production has expanded dramatically in warmer climates around the world. For example, carrot production in Bangladesh has risen significantly in recent years. Since most of the global incidence of Vitamin A deficiency is in warmer regions of the world, the development of carrot cultivars adapted to subtropical climates takes on even greater potential importance. Cultivated carrot germplasm is genetically and phenotypically diverse, and crossable wild relatives are a reservoir of even more genetic diversity. Wild carrot germplasm has been collected in very warm, dry, and, in some cases, very saline sites, and this germplasm is available in the USDA carrot germplasm collection. This project evaluated carrot wild relatives and cultivated carrots in warm, dry, saline field conditions, intercrossed climate-tolerance from wild relatives to adapted, nutritious cultivated germplasm, and evaluated intercrosses among carrots and their derivatives in hot, dry, saline field sites in Bangladesh and Pakistan. Exposure to heat and salinity in field trials was effective in limiting growth for most of the germplasm entries evaluated, whereas exposure to drought did not limit carrot growth as dramatically as heat or salt. Of particular interest, a few entries demonstrated heat, drought, and salinity tolerance in both Bangladesh and Pakistan. Intercrosses involving plants with novel abiotic stress resilience traits of carrot crop wild relatives (CWRs) with highly nutritious, good flavor, widely-grown carrot types were initiated in both Bangladesh and Pakistan, and seed production was successful in subsequent generations. Tolerance for heat, salinity, and drought was discovered among carrot germplasm accessions evaluated, and, for selected entries, was reliably demonstrated across both locations and across several years. Interestingly, among tolerant germplasm accessions, many were cultivated carrot. While wild carrot relatives also demonstrated repeatable tolerance, the incidence of tolerant cultivated carrots suggests that genes in cultivated background can be tapped to develop breeding populations with good horticultural quality favorable to both farmers and consumers. The inheritance of tolerance is being evaluated and germplasm is being developed.

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Growth Chambers and Controlled Environments 2 (Poster)

High Tunnel Systems for Producing Annual Cut Flowers in the Intermountain West
(Poster Board #151)

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Flowers in the Intermountain West

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Small farms in the Intermountain West are using high tunnels to expand their production season for high value crops such as fruits and vegetables. Cut flowers are one potential high value crop that hasn’t been fully explored, partly due to a lack of region-specific information. A research project is underway at the Utah State University research farm in North Logan, Utah to develop appropriate management strategies for two representative cool-season annual cut flower crops (snapdragon and sweet pea). Replicated plots of ‘Rocket’ snapdragon, and the sweet pea cultivars ‘Mammoth’, ‘Elegance’, ‘Royal’, and ‘Spencer’ were planted in high tunnels in early April to May of 2017, with comparison field plantings in late May. Stems were harvested 3 days per week and evaluated for yield (stem number), marketable stems, and length of harvest season. Results from 2017 indicate an increase in quality and stem length of snapdragons grown in high tunnels, compared to the field. Sweet peas showed increased quality during cooler months in high tunnels. For 2018, earlier planting dates were included for both sweet pea and snapdragon, and the snapdragon cultivars ‘Potomac’, ‘Animation’, and ‘Chantilly’ were tested. Cool season annual cut flowers are showing promise as a high-tunnel crop for local markets in the high-elevation Intermountain West.

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Performance of Crop Species with Different Thermal Requirements in Aquaponics Systems
(Poster Board #154)
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Aquaponics is a new emerging agricultural production system that recycles residual nutrients resulted from fish waste for crop production. The culture environment in aquaponics is different from traditional farming, and a good aquaponics system should be designed to meet the growth requirements for fish, microbes, and plants production at the same time. Due to the excellent adaptability to a fluctuating water environment, tilapia (Oreochromis niloticus), a warm-water fish species, is the most popularly grown in commercial and scientific aquaponics systems in the United States. The temperature environment of warm-water aquaponics system does not match with many vegetables popularly grown in aquaponic systems, most of which are cool-season crop species; however, there is no relevant information regarding this aspect. In order to compare the performance of crop species with different thermal requirements in warm-water aquaponics systems, two warm-season crops, cherry tomato (Solanum lycopersicum) and basil (Ocimum basilicum) and one cool-season crop lettuce (Lactuca sativa), were grown with tilapia for 2 months. Fish were fed once a day by 1% fish fresh weight. Water quality parameters were measured daily. The pH was adjusted by using a mixture of potassium hydroxide and calcium hydroxide (v:v = 1:1) at around 7.0. Water was sampled for total ammonium nitrogen (TAN), nitrite, nitrate, and phosphate measurement every three days. At the beginning and harvest, crop growth parameters were measured. Bio-filter mediums were sampled for bacteria DNA extraction by qPCR with amoB as a molecular marker to check the population of ammonia-oxidizing bacteria (AOB) weekly during study period. Data showed that cherry tomato showed significantly higher SPAD than basil and lettuce, while both cherry tomato and basil showed significantly higher photosynthesis rate (Pn) values than lettuce. In addition, there was significant linear correlation between leaf temperature and net photosynthesis in cherry tomato and basil-based aquaponics systems, while no correlation was found in lettuce-based aquaponics systems between the two variables. Further, the results showed that higher leaf temperature increased net photosynthesis rate in cherry tomato and basil-based aquaponics systems, which may be partly explained by their higher thermal requirements. However, there was no significant difference in weekly AOB population density among the treatments, indicating that AOB did not play a critical role in plant growth variations. In summary, warm-season crops showed better growth performance in tilapia-based warm-water aquaponics systems.

Specified Source(s) of Funding: USDA-AFRI

Effects of Plant-derived Protein Hydrolysate Biostimulant on Adventitious Rooting in Cuttings of Basil, Tomato, and Chrysanthemum
(Poster Board #155)
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Biostimulants, formulated products of various biological origins, have been considered as innovative tools to improve plant productivity by enhancing nutrition efficiency, abiotic stress tolerance, and quality parameters for crop production. Among all biostimulant groups, plant-derived protein hydrolysate group have gained in popularity due to its effectiveness. Plant propagation by stem cuttings is a general method for the commercial production of many greenhouse crops, with auxin being the main rooting hormone. The aims of this study were to identify the biostimulant action (hormone like activity) on adventitious rooting of cuttings and to determine its ideal concentration for the maximum rooting responses of cuttings. A biostimulant (Quik-Link) containing lignosulphonate and protein hydrolysates derived from legume seeds was utilized in the cuttings of three different plant species, basil, tomato, and chrysanthemum. Unrooted cuttings of the plant species were either purchased

An asterisk (*) following a name indicates the presenting author.
from a commercial source or taken from stock plants grown in the greenhouse. Ten to 20 replicates of each plant species were treated with either biostimulant at five different concentrations (0, 0.1, 1, 5, and 10 g/L), or rooting hormone (Dip’N Grow) at five different concentrations (0 ppm, 100 ppm, 200 ppm, 300 ppm, and 500 ppm) for comparison. The cuttings were then planted in a propagation tray filled with soilless media and placed under intermittent mist where optimum temperature, humidity, and lighting were provided for rooting. Maximum rooting occurred in 3 weeks and percentage of rooting, root growth, and shoot growth were measured. The results demonstrated that the biostimulant showed auxin-like and gibberellin-like activities, noticeably increasing both root and shoot growth. It significantly enhanced the number of root and volume, and root dry weight, as well as stem length and shoot dry weight. Overall, plant cuttings treated with 5 g/L of the biostimulant showed the maximum effectiveness in adventitious rooting. The findings suggest that the treatment of unrooted cuttings with the biostimulant can significantly improve adventitious rooting in basil, tomato, and chrysanthemum. Interestingly, it was also found that the biostimulant can perceptibly enhance the number of roots in a different way unlike auxin.

Specified Source(s) of Funding: NE-1335

**Effects of Plant-derived Protein Hydrolysate Biostimulant on the Productivity and Quality of Lettuce and Tomato (Poster Board #156)**

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The use of biostimulants has been proposed as an innovative and promising approach to improve crop quality and yield. Among all biostimulant groups, plant-derived protein hydrolysate are gaining interest globally due to their remarkable agronomic value compared to other groups. In general, greenhouse production system is known as a high input system where high levels of fertilizers were consumed for intensive plants growth. In this study, a type of biostimulant, legume-derived protein hydrolysate, was used to improve crop quality and yield, while reducing fertilizer inputs for crop production. A series of experiments were conducted in the greenhouse to identify the effects of biostimulant on romaine lettuce ‘Sarah’ and dwarf tomato ‘Micro-tom’ on plant performance, which includes leaf/stem/root length, leaf number/area, root diameter, photosynthetic gas exchange, chlorophyll content, and crop yield. Treatments consisted of two levels of biostimulant (0 and 3 g/L biostimulant), which were combined with either nitrogen (N) treatments (low, medium, and high) or electrical conductivity (EC) treatments (low, medium, and high) with commercial fertilizer (4.5N–14P–34K). A solution of 50 ml containing biostimulant was applied to romaine lettuce and micro-tom as soil drenching once every week during production period. The results showed that leaf area and head fresh weight of romaine lettuce were increased by 11% and 15%, respectively, when 3 g/L biostimulant was applied with low nitrogen or low EC treatment. Even though the micro-tom experiment is currently ongoing, we observed similar results as romaine lettuce and tomato plants applied with biostimulants have already shown better performance, particularly under low nitrogen and low EC treatments. Based on our findings, it is concluded that biostimulant improves productivity and quality of both romaine lettuce and tomato under low nutrition conditions. This suggests that the plant-derived protein hydrolysate application may contribute to the reduction of fertilizer inputs in greenhouse production systems.

Specified Source(s) of Funding: NE-1335

**The Effect of Wavelength Specific Lighting on Whole Plant CO₂ and H₂O Gas Exchanges**

*(Poster Board #157)*

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Advancements in light-emitting diode (LED) technology have made them a viable alternative to current lighting systems for both sole and supplemental lighting requirements. Much research is available on the wavelength specific responses of leaves from multiple crops when exposed to long-term wavelength specific lighting. However, leaf responses to environmental stimuli do not always extrapolate linearly to whole plant responses due to the complexities of the plant canopy, namely mutual shading and leaves of different ages. For these reasons, we measured the diurnal whole plant CO₂ and H₂O gas exchange of vegetative tomato plants under both long-term and short-term exposure to various spectral qualities as well as ambient and elevated CO₂ conditions. It was determined that within each environmental stimulus provided to the plant, biomass gain throughout the day was similar when plants were measured under high-pressure sodium (HPS), red-blue LED, or red-white LED. Under all luminary systems, tomato plants showed a similar diurnal pattern of transpiration, rising to a maximum around mid-day and declining during the remainder of the photoperiod. However, plants measured under the LED lighting systems produced higher transpiration rates than plants measured under HPS lights. This conversely lead to decreased water-use-efficiency (WUE) rates throughout the day. The decrease in WUE from plants exposed to both LED systems was ubiquitous within all lighting and CO₂ conditions tested. The understanding of the effects of wavelength specific lighting on both CO₂ and HO₂ canopy gas exchanges have significant implications for both academic research where plants are cultivated in...
controlled research environments and commercial greenhouse production.

**Specified Source(s) of Funding:** Agriculture & Agri-Food Canada

**Image Analysis Technique for Remotely Estimating Light Absorption Efficiency in Plants Grown in Controlled Environment Agriculture (Poster Board #158)**

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Artificial lighting is required in indoor production while it improves crop quality for year-round greenhouse production. Artificial light provided to plants is intercepted and transmitted by the canopy. The intercepted light is absorbed and a portion of the light is reflected back. Reflected light is wasted if plants do not reabsorb it. Extent of light reflection can further increase under stress conditions. Artificial light provided to plants can be significantly high, therefore it is important to minimize any wastage of provided light. Continuous monitoring of light absorption efficiency of plants can aid in reducing artificial light wastage. Currently available sensors (e.g., quantum sensors, spectral reflectance sensors) are not designed to measure light absorption efficiency of whole-plants. There is an urgent need to develop simple, accurate and affordable sensing techniques to estimate light absorption efficiency of plants. The objective of this study is to test the efficacy of image analysis technique for estimating light absorption efficiency of plants in controlled environment agriculture. For testing this technology, petunia (*Petunia x hybrida* L. ‘Easy Wave Red Velour’) seedlings were transplanted in a greenhouse maintained at 26/20°C (day/night) temperature and daily light integral (DLI) of 10–20 mol·m⁻²·d⁻¹. Plants were subjected to optimum and stresses treatments including water stress, nitrogen stress and low light stress. Direct measurements such as, light absorption efficiency (ratio of absorbed to incident light intensity, \( PPF_{ai} \)), photosynthesis rate \( (A) \) and shoot dry weight \( (SDW) \) were taken. A multi-spectral imaging station with image analysis software was used for image acquisition, plant pixel segmentation and plant reflectance measurement at different visible (450, 523, 591, 625, 660 nm) and near infrared (\( nir \), \( 870 \) nm) wavebands. Mean reflectance of visible wavebands (RVIS) from groups of plants was calculated and expressed as relative reflectance of light in visible wavebands (RVIS/R870). Results showed RVIS/R870 was inversely related to \( PPF_{ai} \) and SDW. Petunia plants subjected to stress showed increased light reflectance (or absorbed less light) likely due to \( A \) under stress. These results indicate that image-based measurements (RVIS/R870) can be used to indirectly estimate light absorption efficiency in plants.

**Automated and Non-destructive Measurement of Plant Growth Characteristics Using a Multispectral Image Based Technique in Controlled Environment Agriculture (Poster Board #159)**

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Intensive farming, high plant densities, and multi-level production makes it challenging to monitor plant growth and input use in controlled environment agriculture (CEA, greenhouses and vertical farms). With the advancements of imaging technology, remote observations using drones is already used in outdoor agriculture systems. Image based measurements using cameras in CEA can make monitoring crops more efficient. Our objective was to test whether a multi-spectral image analysis technique can be used to remotely and automatically measure plant growth characteristics in CEA. Experiments were conducted in a greenhouse maintained at 26/20°C (day/night) temperature and daily light integral (DLI) of 10–20 mol·m⁻²·d⁻¹. Leaf lettuce (*Lactuca sativa* L. var. Black Seeded Simpson) and tomato (*Solanum lycopersicum* var. Early Girl) were grown in a peat-based substrate (Sungro Professional Mix) and supplied with a liquid fertilizer comprised of 15–5–15 and 21–5–20 mixes in 3:1 ratio. Leaf lettuce and tomato plants were grown under non-stress conditions in the experiment. A multi-spectral imaging station with image analysis software was used for image acquisition, plant pixel segmentation, and canopy area estimation. Image based canopy area \( (LAI_{image}) \) was measured for groups of plants on different days. Immediately after imaging, direct measurements included total leaf area \( (LAI_{actual}) \), shoot dry weight \( (SDW_{actual}) \), and relative growth rate \( (RGR_{actual}) \). There was a linear relation between \( LAI_{actual} \), \( SDW_{actual} \) and \( RGR_{image} \) in leaf lettuce and tomato. These results indicate that image-based measurements can non-destructively measure plant growth characteristics. Automated non-destructive growth measurements using camera based image systems can be mounted on moving systems (ex: booms) or placed at stationary locations in CEA. These systems can aid in early detection of production related issues affecting growth, thereby leading to increased productivity in CEA.

**Specified Source(s) of Funding:** Purdue Univeristy

**Low Tunnel and Planting Dates Affected Yield and Growth of Organically Managed, Field Grown Day-neutral Strawberries (Poster Board #160)**

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Planting date and low tunnel could play important roles in the annual plasticulture strawberry system. The objective of this study was to determine the effect of low tunnel and planting dates on the growth and early and total yield of day-neutral strawberries in North Carolina. Cultivars Albion and San Andreas were planted on September 1 (D1) & 29 (D2) in raised beds with low tunnels (LT) and without low tunnels (NLT) on NC A&T State University farm in Greensboro, NC (hardiness zone 7b). LT was used from October through May of both 2016/17 and 2017/18 seasons. Yield and bloom data were taken twice/week, while canopy and biomass data were taken monthly from October to May. In the 2016/17 season, no significant difference in total yield occurred between D1 & D2 and between LT & NLT. LT and D2 had numerically higher marketable yield (57% and 53%) compared to NLT and D1 (45% and 48%). The marketable and total yield from October to January, in April or May were not affected by LT and PD. However, LT significantly increased the total and marketable yield compared to NLT in period from January to March, and D2 plants had significantly higher yield than D1 plants (total yield of 24.56 vs 13.28 g/plant and marketable yield of 18.10 versus 8.04g/plant). LT and D2 plants had smaller canopy size and biomass, and LT also delayed the days to 1st bloom and 1st harvest by 13 and 29 days, respectively, compared to NLT. In the 2017/18 season, LT numerically increased the total and marketable yield than NLT for D1 plants (total yield of 51.13 versus 35.39 g/plant and marketable yield of 49.47 versus 23.8 g/plant) before winter. LT shortened days to 50% bloom by 20 or seven days compared to NLT for D2 or D1 plants, respectively. The 2017/18 research is still ongoing, but based on the results so far, LT and D2 should be recommended for higher marketable yield before winter.

Rapid Light Response Curves As a High-throughput Screening Method for Photochemical Responses of Bedding Plants
(Poster Board #161)
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Understanding plant photochemical responses to photosynthetic photon flux density (PPFD) is important for developing energy-efficient supplemental lighting strategies. However, the photochemical light response varies greatly among species and cultivars, and a rapid, reliable method to describe species- and variety-specific photochemical responses is needed. Chlorophyll fluorescence measurements were used to determine the electron transport rate (ETR) of six bedding plant species: Begonia semperflorens ‘Ambassador Scarlet’ (begonia), Catharanthus roseus ‘Jams N Jellies Blackberry’ (vinca), Impatiens walleriana ‘Super Elfin Violet’ (impatiens), Pelargonium hortorum ‘Maverick Violet’ (geranium), Petunia ×hybrida ‘Daddy blue’ (petunia), and Salvia splendens ‘Mojave’ (salvia). Diurnal measurements were conducted in a greenhouse with fluorescence measurements taken every 15 min during the day and hourly at night with 5 measurement days per species. Additional measurements were taken in a growth chamber using a hyperbolic series of PPFDs (0, 50, 150, 300, 500, 750, 1050, 1400 µmol·m⁻²·s⁻¹), with 20 min acclimation at each intensity, and 5 replications per species. For 4 species, the data collected in the growth chamber was similar to the greenhouse data, but for impatiens and petunia observed ETR was generally lower in the greenhouse. This may have been due to physical damage to the leaves induced by the fluorometer leaf clip. In all cases, an asymptotic rise to a maximum function fit the data well. This function uses only two variables: the initial slope and the asymptote of the ETR response curve: \[ \text{ETR} = \text{[asymptote of ETR]} \times [1- e^{-(\text{initial slope of ETR} - \text{asymptote of ETR})}] \times \text{PPFD}]. \] Accordingly, it was hypothesized that the photochemical light response could be adequately described by determining only the initial slope and asymptote: a rapid light response curve. This was tested in a growth chamber by measuring the ETR of each species at a very low (≈3 µmol·m⁻²·s⁻¹) and very high (≈2100 µmol·m⁻²·s⁻¹) light intensity for 5 min. The equation generated from this data fit the greenhouse ETRs with a mean $R^2 = 0.93$ and slope of 0.89; the estimated values were generally 11% higher than the observed ETRs. Similarly, it fit the previous growth chamber data with mean $R^2 = 0.96$ and slope of 0.94 (estimated 6% higher than observed) for all species except for impatiens, which had a much higher slope (m = 1.5, $R^2 = 0.94$), suggesting that the high PPFD used to determine the asymptote was photoinhibitory for impatiens. This high-throughput method accurately describes the ETR response for 5 of the 6 species.

Response of Tomato ‘Merlice’ to the Interaction of Daily Light Integral and Carbon Dioxide Concentration (Poster Board #162)
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Of all tomatoes consumed in New York State less than 10% are grown within state, creating a void in the availability of locally produced tomatoes. Greenhouse tomatoes are the largest greenhouse vegetable crop produced in the United States with over $400 million annual wholesale value. One of the challenges associated with growing tomatoes in upstate New
York is the energy demands for heating and lighting. Use of supplemental CO₂ can reduce the need for supplemental lighting and increase crop yield in off-season. While CO₂ enrichment is known to increase crop yields, scientific literature is lacking on the interaction between CO₂ concentration and daily light integral (DLI) and subsequent photosynthetic and yield response of tomatoes. The objective of this research is to study the interaction of supplemental CO₂ and lighting on tomatoes at different developmental stages. Phase 1 of this experiment uses climate controlled mini-chambers with 16 different treatment combinations conducted using four different CO₂ concentrations (400, 600, 800, 1000 ppm) and light intensities (10, 15, 20, 25 mol·m⁻²·d⁻¹ PAR) on juvenile “Merlice” tomato plants. After 10 days of exposure, plants are assessed for biomass, photosynthetic parameters, and morphological differences. An equation relating plant biomass and net photosynthetic assimilation based on CO₂ and DLI is under development. In Phase 2, CO₂ and DLI will be controlled in a greenhouse to determine responses at the tomato fruiting stage.

Specified Source(s) of Funding: NYSEDA GLASE

Effects of Temperature and Potassium on Lettuce Biomass, Quality, and Phytonutrient Concentrations in a Controlled Environment

(Poster Board #163)

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Lettuce is an economically important crop that generates sizeable income for small and medium-sized growers in the southeastern United States. When produced in adverse environmental conditions, lettuce is vulnerable to yield losses and deterioration of quality. Previous research has indicated that elevated levels of potassium (K) positively affects the quality of several fruits and vegetables, including strawberry, melon, pepper, and tomato. However, research concerning the impact of elevated K levels on leafy vegetables, such as lettuce, is lacking. Therefore, seeds of dark-red ‘Lollo’ lettuce were sown in a soilless medium and germinated under greenhouse conditions at 25/20 °C (day/night). Upon emergence of the first true leaf, plantlets were transferred into 11-L Rubbermaid® plastic containers and placed into growth chambers at 25 and 33 °C. Plants were produced with increasing K treatments of 117.3 (control), 234.6 (2x), 469.2 (4x), and 4) 938.4 (8x) mg·L⁻¹. Plants were harvested 30 days after seeding. Increasing K treatments resulted in a negative quadratic response on lettuce dry mass and generated 14% more leaf calcium at 234.6 mg·L⁻¹ compared to the control treatment. Increasing temperature from 25 to 33 °C resulted in the increased leaf dry matter and biomass by 40% and 43%, respectively. Conversely, leaf water content increased by 3% from 25 to 33 °C. Increasing nutrient solution K alone did not affect lettuce quality (phenolics and mineral content). However, plants produced at 33 °C showed a greater accumulation of quercetin glycosides compared to plants produced at 25 °C. Additionally, interactions between temperature and K treatment influenced leaf concentrations of phosphorous, sulfur, and copper. The results from this study suggest that temperature is a stronger regulatory factor than increasing K in the determination of lettuce yield and quality; however, increasing K concentration to 234.6 mg·L⁻¹ results in greater concentrations of leaf mineral content without compromising plant yield.

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The Effects of Environment and Nutrient Solution Concentrations on Hydroponic Lettuce Yield, Quality, and Phytonutrients

(Poster Board #164)

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In response to increasing interest in greenhouse production and difficulties imposed by adverse environmental conditions in the southeastern United States, a study was conducted with green and red-leaf lettuce cultivars grown in a deep-water culture production system. Plants were seeded in Rockwool and germinated under greenhouse conditions (Verona, MS; 34° N Lat.) at 25/20 °C (day/night) for 21 days before transplanting. The experimental design was a randomized complete block with a 2 x 3 factorial arrangement of cultivar and nutrient treatments that consisted of six replications, with individual tubs representing an experimental unit. Treatments consisted of two lettuce genotypes 1) green (Winter Density) and 2) red (Rhazes) and three nutrient treatments containing electroconductivity (EC) levels of 1) 1.0, 2) 2.0, and 3) 4.0 mS·cm⁻¹. After 50 days, plants were harvested, processed, and analyzed to determine marketable yield, biomass, plant height, and stem width. Additionally, nutritional quality was assessed by determining flavonoid and phenolic content and leaf elemental nutrient concentrations. Project results demonstrated that the interaction between growing season and lettuce cultivar was the predominant factor influencing yield, biomass, and plant quality. Nutrient solution EC treatment significantly affected shoot dry mass, biomass, and water content. EC treatment also significantly impacted the concentration of 3-O-glucoside and uptake of phosphorous, potassium, iron, boron, zinc, and molybdenum. Results from this study indicate that the effects growing season and cultivar on leafy lettuce performance (yield and quality) was more pronounced than the effect of nutrient solution EC treatment. However, despite statistical insignificance, all elemental nutrients increased with increasing solution EC. Thus, greenhouse production of green...
and red-leaf lettuce cultivars in the southeastern, United States should be conducted in the spring and fall growing seasons with elevated nutrient solution EC of \(\approx 4.0 \text{ mS cm}^{-1}\) to maximize yield and quality. The current study may spur research into the performance outcomes of increasing individual solution nutrients in conjunction with production season and green and red-leaf lettuce cultivars.

**Specified Source(s) of Funding:** This study was a contribution of the Mississippi Agriculture and Forestry Experiment Station and USDA-NIFA Hatch S294 project MIS 146030

**Applied Effect of a Modified Open-top Chamber Simulated at Elevated CO\(_2\) Concentration in Goji Berry (Lycium barbarum L.)**

*(Poster Board #165)*

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Enhancement of carbon dioxide (CO\(_2\)) in the atmosphere has received great attention due to its potential repercussion on global warming and direct effects on the vegetation, especially with a potential increase in atmospheric CO\(_2\) level from 400 \(\mu\text{mol mol}^{-1}\) to 1000 \(\mu\text{mol mol}^{-1}\) by the end of the 21st century according to the currents environmental studies. Therefore, development of new technologies on controlled environment conditions are needed to investigate plant response to CO\(_2\) enhancements and its possible repercussion on world food security. In the present study, we aimed to evaluate a modified open-top chamber (OTC), designed and constructed based on previous OTC experiences, which provides precise control of CO\(_2\) under different concentrations, with excellent control of air temperature and humidity. To test the functionality of the modified OTC, Goji berry (Lycium barbarum L.) plants were grown from May to Oct.2017 inside the chambers. Real-time data of CO\(_2\) concentration, temperature, and air relative humidity of the chambers were collected. As a result, the average CO\(_2\) levels obtained in the chamber during the study period was 369.33 \(\mu\text{mol mol}^{-1}\) for ambient conditions, while elevated group 1 and group 2 showed concentrations of 558.35 \(\mu\text{mol mol}^{-1}\) and 772.71 \(\mu\text{mol mol}^{-1}\) respectively. The fluctuation for elevated group 1 ranged from 551.82 to 572.40 \(\mu\text{mol mol}^{-1}\) with a variation amplitude of 20.57 \(\mu\text{mol mol}^{-1}\). In the elevated group 2, the range of CO\(_2\) concentration was from 756.71 to 779.79 \(\mu\text{mol mol}^{-1}\) with variation amplitude of 23.09 \(\mu\text{mol mol}^{-1}\). In addition, no significant differences were found in temperature and air relative humidity among the chambers treatments (\(P > 0.05\)). Meanwhile, the measured amounts of fructose, glucose, sucrose and starch contents of Goji berry fruits revealed that the sugar content of the fruit was significantly reduced under elevated group 2 CO\(_2\) concentration, there was a significant increase (\(P < 0.05\)) in the activity of sucrose cleavage enzyme and a decrease in the sucrose synthetic enzyme. These results demonstrated precise control of CO\(_2\) concentration, temperature, and humidity inside the modified OTC chambers, showing an excellent development of CO\(_2\) effect improvement on Goji berry, and it can be used to test climate change response in other plant species.

**Specified Source(s) of Funding:** The National Natural Science Foundation of China (No. 31660199, 31160172)

**Controlled Temperature Treatments with Low-cost, Off-the-shelf Equipment for Bud or Seed Forcing Experiments**

*(Poster Board #166)*

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Characterizing the regulation of development by temperature requires controlled exposure of replicate plants (whole or in part) to multiple temperature environments simultaneously. Inexpensive access to the number of environmental chambers needed for the parameterizing temperature response curves for development is not common and can limit the scope of experiments. Similarly, these experiments are often also not included in teaching labs to demonstrate the effects of temperature on plant development. We found an inexpensive (< $40) temperature controller designed for use by homebrewers which allows a chest freezer to be tightly regulated to a desired set point across a range biologically relevant temperatures. Set up can be completed in a few minutes. We included a desktop fan for circulation and water ballast to stabilize temperature responses to opening the lid for observations. Temperature data loggers within the chambers recorded standard deviations of approximately 0.25 °C around temperature set points from 3–20 °C. To demonstrate the potential of the chambers we performed two different experiments. First, we used these chambers evaluate temperature effects on ‘time to event’ data for different stages of germination as a laboratory exercise in an undergraduate plant physiology course. Second, we warm forced buds of a woody perennial (peach) at multiple temperatures for the calculation of base temperature and growing degree hour requirement for bud break. For our applications we added flexible strip LED lighting for photoperiod signaling. However, use of the chambers for photosynthetically driven growth may be limited by the lack...
Ornamentals/Landscape and Turf 1 (Poster)

Evaluation of Ornamental Species (Order: Lamiales) for Phytotoxic Response to Various Pesticides in Southeastern United States for Interregional Research Project #4 (IR-4)

(Poster Board #110)

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The Interregional Research Project #4 (IR-4) is a national program which provides pest management solutions for specialty crop growers and was started at the Tifton GA location in 1977. In the last ten years, the IR-4 Project on the U.S. southeastern coastal plain has completed 18 phytotoxicity experiments on six ornamental Lamiales genera including Buddleia, Lantana, Ligustrum, Salvia, Torenia, and Verbena. Four herbicides were applied at label rates as either a broadcast granular or as “over-the-top” foliar sprays. Over this same period, six fungicides and two insecticides were applied using foliar sprays. Field experiments were conducted as randomized complete blocks with replication and pesticide treatments assigned to a specific Lamiales species. Phytotoxicity was recorded on a 0–10 scale (0 = no injury; 10 = dead) at intervals required by the protocol which varied by species and chemical combination. Plant height and width were also measured at initial and final evaluations to assess any adverse chemical impact on plant growth and marketability. Data were analyzed in ARM (Agricultural Research Manager) using ANOVA, with means separated using Fisher’s Protected LSD at a level of 0.05. Results indicated no injury among any of the fungicide or insecticide treatments, but significant differences in phytotoxicity between the nontreated and some of the herbicide treatments. IR-4 research data have contributed to the registration of Actigard, Alibi Flora, Dimension, Echelon, Freehand, Kontos, Orkestra Intrinsic, QRD 416, Tourney, Tower, and Trinity on these Lamiales ornamental horticulture specialty crops.

Evaluation of Twenty-one Kalmia Latifolia L. Cultivars for Container and Landscape Performance in Georgia (Poster Board #111)

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Mountain laurel (Kalmia latifolia L.) is a valuable ornamental shrub due to its attractive foliage and showy flowers. Breeding efforts have led to improved selections that had been developed, evaluated, and distributed in the northeastern United States (U.S.), but being ignored by nursery people and consumers in the southeastern U.S. We conducted a four-year trial to evaluate 21 popular mountain laurel cultivars, primarily developed in the northeastern U.S., for container and field performance in Georgia. All container grown cultivars yielded considerable growth in the first year, indicating growing mountain laurel as one-year container plants was feasible for nurseries. Cultivars displayed significantly different growth index throughout the container trial. Fast-growing cultivars, ‘Bullseye’ and ‘Ostbo Red’, grew to over 100 cm, 150 cm, and 250 cm while slower growers like ‘Firecracker’ and ‘Tinkerbell’ had less than 20 cm, 115 cm, and 180 cm in one, two, and four years, respectively. Cultivars were classified into five groups, which were dwarf habit with pink flower, dwarf habit with non-pink flower, non-dwarf habit with green stem and white flower, non-dwarf habit with pigment-patterned flower, and non-dwarf habit with pink flower. This information provided growers on how to select various cultivars for their production among groups. In the field study, performance rating of 21 cultivars ranged from 2.0–4.8 (out of 5.0) in 2014 and from 2.0–5.0 in 2015 and significant differences were observed in 2014. Ten cultivars received the highest ratings over the two years were selected for the subsequent field trial in 2016. Cultivars showed overall decreased ratings (1.0–3.3) from the previous two years because of late spring planting and relatively unfavorable soil conditions. ‘Ostbo Red’, ‘Pristine’, and ‘Tinkerbell’ had higher performance rating, more net growth, and less decrease in maximum quantum yield, which indicated their adaptation to the southeastern environmental conditions. Nursery growers and consumers should benefit from our regional cultivar trial information and we recommend ‘Ostbo Red’, ‘Pristine’, and ‘Tinkerbell’ for the southeastern landscapes based on their superior container and field performance, leaf spot resistance, and morphological variations.

Colocasia Trials at Stephen F. Austin State University (Poster Board #112)

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An asterisk (*) following a name indicates the presenting author.
Diversity amongst and within species is a cornerstone of horticulture. However, with such great diversity comes the need for academics, breeders, growers, landscapers, retailers, public gardens, and home gardeners to know how plants are going to perform in their region. Plant trials and trial gardens help to provide that information to these various entities so that wise decisions can be made about plant choice. In July 2016 a new genera trial garden was started at Stephen F. Austin State University in east Texas to evaluate 46 Colocasia cultivars over a three year period. To reduce bias, data was collected by two trained undergraduate students and included plant performance on a 1 (poor) to 5 (outstanding) scale, plant height, and plant width. Based on two years of data, ‘Madiera’, ‘Red Eyed Gecko’, and ‘Ruffles’ were three of the best cultivars who averaged a performance over 3.5. Our data on height and width will be beneficial for those who grow and install Colocasia in ornamental landscapes.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation

Effects of High pH Substrate on Growth and Foliar Chlorosis of Iowa Grown River Birch Provenances (Poster Board #113)

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River birch (Betula nigra L.) is a common landscape shade tree known to develop iron deficiency interveinal leaf chlorosis (IFC) when grown in high pH and CaCO₃ soils. While variation in symptomology has been observed, provenances endemic to high pH soils may not always display chlorosis. The increased interest for environmentally sustainable landscape selections could be made if additional screening was conducted to determine their potential adaptability to high pH and CaCO₃ soils. The first study (Expt. 1) evaluated open-pollinated (OP) seedlings of Iowa provenances and ‘BNMTF’ OP in an elevated pH substrate. A second study (Expt. 2) evaluated clones from selected Iowa provenances, ‘BNMTF’, ‘Cully’, and ‘BNMTF’ OP. Twice-weekly 120 mL drenches of 4.8% CaCO₃ were used to maintain an elevated pH substrate. In Expt. 1, leaf chlorophyll was reduced by 36% in elevated pH substrate (pH = 7.57) compared to the control (pH = 5.57) (16.95 and 26.39 μg·cm⁻², respectively) with differences in seed sources observed. A seed source from Bearbower Sand Prairie, Buchanan Co., IA (BSP3) had the greatest leaf chlorophyll content (25.86 μg·cm⁻²) but was not statistically greater than two sources from Clemons Creek WMA, Washington Co., IA (23.90 μg·cm⁻², CCWMA1 and 22.76 μg·cm⁻², CCWMA2). Total leaf iron (Fe) concentrations were reduced by 61% for sources growing in the elevated pH substrate. In Expt. 2, leaf chlorophyll was reduced by 32% in elevated pH substrate (pH = 7.00) compared to the control (pH = 5.29); (19.40 and 28.73 μg·cm⁻², respectively). An Iowa clone, CCWMA3, had greater chlorophyll content than some other sources (26.78 μg·cm⁻²) but no greater leaf chlorophyll content than ‘BNMTF’ (25.70 μg·cm⁻²), a source from Cih Fen, Johnson Co., IA (24.95 μg·cm⁻², CF3), and a source from Princeton WMA, Scott Co., IA (24.13 μg·cm⁻², PWMA2). ‘Cully’ had lower leaf chlorophyll (21.87 μg·cm⁻²) than CCWMA3 and ‘BNMTF’. Total leaf Fe content was also reduced in elevated pH substrate for all sources compared to their controls. Based on our studies, these Iowa provenances did not sequester more substrate Fe in their leaves than the industry standards, but two selections (BSP3 and CCWMA3) were perhaps more Fe efficient, because they were considerably less chlorotic than ‘BNMTF’ OP and ‘Cully’. These Iowa seed sources and clones should be further evaluated in field studies to determine their extent of Fe-use efficiency in high pH soils compared to popular industry cultivars.

An asterisk (*) following a name indicates the presenting author.

Anthocyanins in Flowers of Redbud (Cercis sp.) As Potential Natural Colorants (Poster Board #114)

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Redbud (Cercis sp.) is used globally as a spring flowering ornamental tree or shrub. Interest in colorants from plants to replace synthetic dyes used in foods has greatly increased in the last 10 years. Redbud flowers are of interest as a natural pigment source as they do not brown with senescence and all parts of the flower contain pigment. In this study, redbud flowers of 12 cultivars and lines, primarily from Cercis canadensis, were collected and anthocyanin pigments determined by high performance liquid chromatography and diode array detector. The anthocyanins cyanidin-3-glucoside, petunidin-3-glucoside, peonidin-3-glucoside, malvidin-3-glucoside, and 3,5-diglucosides of delphinidin, cyanidin, and petunidin were found in purple, rose, and red-purple redbud flowers. An acylated malvidin 3-glucoside was also present. Malvidin 3,5 diglucoside was the dominant pigment (60%) in the red-purple ‘Appalachian Red’ and ‘Crosswick’s Red’ while cyanidin 3-glucoside was present in 15–25% of flowers from the purple type cultivars such as ‘Oklahoma’, ‘Forest Pansy’ and ‘Traveller’, ‘Ruby Falls’ was intermediate (50%) in both cyanidin-3-glucoside and malvidin-3,5-diglucoside. Total amounts of anthocyanin were highest in ‘Oklahoma’, ‘Appalachian Red’, and ‘Ruby Falls’; and were 2–3 g cyanidin 3-glucoside or malvidin 3,5 diglucoside/kg dry weight. In comparison, blackberries contain 15–25 g cyanidin 3-glucoside/kg dry wt and ‘Concord’ grape juice contains about 5 g malvidin 3,5 diglucoside/kg dry weight.

Evaluating Pollinator Visitation of Native Shrubs and Nativars (Poster Board #115)

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There is increased interest in native plants for landscaping to support pollinators. The majority of native plants sold by nurseries are cultivars. Some consumer and conservation groups question the suitability of native cultivars (nativars) to support pollinators. This work evaluated insect pollinator visitation for five native shrub species, and one or more cultivars of each species. The following species were installed in a full sun field behind the University of Connecticut Floriculture Greenhouse Facility in a randomized complete-block design with three replicates: *Aronia melanocarpa*, *A. melanocarpa* ‘UCONNAM012’ Low Scape®, *Rubus* 'UCONNAM165’ Low Scape®, *Clethra alnifolia*, *C. alnifolia* ‘Hummingbird’, *C. alnifolia* ‘Ruby Spice’, *Dasiphora fruticosa*, *D. fruticosa* ‘Goldfinger’, *D. fruticosa* ‘Pink Beauty’, *Hydrangea arborescens*, *H. arborescens* ‘Annabelle’, *Physocarpus opulifolius*, and *P. opulifolius* ‘Monlo’ Diablo®. During the bloom period for each plant, insect visitation was measured on ten different occasions using visual observation with each observation period lasting 5 minutes. There was no significant difference in insect visitation between *A. melanocarpa* and its cultivars and *C. alnifolia* and its cultivars. Eighty percent of insect pollinators visiting *Clethra* species were bumblebees (Bombus sp.). Overall, *D. fruticosa* and its cultivar ‘Goldfinger’, both of which have yellow flowers, attracted more insects than *D. fruticosa* ‘Pink Beauty’, which has pink flowers. *H. arborescens* and *P. opulifolius* attracted more total insect pollinators than their respective cultivars. *H. arborescens* attracted 4 times as many bumblebees, 2 times as many other bees (clade Anthophila), and 2 1/2 times as many wasps (suborder Apocrita) than did its cultivar, ‘Annabelle’. *P. opulifolius* attracted more honeybees (*Apis mellifera*) and mining bees (family Andrenidae) than its cultivar ‘Monlo’, but ‘Monlo’ attracted more hoverflies (family Syrphidae) than the straight species.  

**Microscopy Studies of Eriophyid Mites on Roses in the United States** *(Poster Board #116)*

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A survey of roses from several states within the US was conducted to identify eriophyoid mite species associated with Rosa spp. Various microscopy techniques including bright field, phase contrast, differential interference contrast light microscopy, transmission scanning electron microscopy and low temperature scanning electron microscopy were used. Three species of eriophyid mites were discovered, *P. fructiphilus*, *Eriophyes eremus*, and *Callyntrotus schlechtendali*. Phyllocoptes fructiphilus is the mite vector for an Emaravirus, Rose rosette virus (RRV), the causal agent of rose rosette disease (RRD). This mite was found primarily under the petioles (stipules), inside the flower sepals appressed to the ovary/seed and on open leaves during the growing season. This mite often hides amongst dense simple and bulbous, glandular hairs (trichomes) or under stipules/petioles. *Eriophyes eremus* has been found under the stipules and is now recorded for the first time on the American continent. *Callyntrotus schlechtendali* was found on the open leaf surface. The latter two species were not associated to obvious plant injury. In addition, predatory mites that were found associated with these eriophyid mites may be useful as biological control agents.

**Specified Source(s) of Funding**: NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

**A Cost-Effective Technique for Counting Phyllocoptes Fructiphilus, an Eriophyid Mite Vector of the Rose Rosette Virus** *(Poster Board #117)*

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Rose rosette disease is vectored by the eriophyid mite, Phyllocoptes fructiphilus. Due to its small size, detecting and evaluating management strategies for *P. fructiphilus* on roses in nursery, commercial, public, and private settings is difficult. Methodology has been published for counting eriophyid mites in laboratory settings, but equipment costs (excess of $9,000 U.S. in some cases) prohibits many individuals from counting eriophyid mites on their roses. The objective of this study was to develop a simplified technique for eriophyid mite counts with readily available materials and a combined cost $100 or less. An eriophyid mite counting kit was developed, that achieves...
this goal. Main kit components include: containers for sample transport, pollen sieves for mite isolation, and an inexpensive microscope for mite detection and population estimation. Also included is a handbook containing equipment descriptions, costs, and protocols for mite collection, extraction, and population estimation. Nineteen kits have been distributed to nursery owners, professionals who maintain rose gardens, and private garden owners. Each kit recipient was asked to fill out a survey on kit ease-of-use and results satisfaction for kit improvement. Distinguishing eriophyid mite population increases on rose plantings will aid nursery and landscape professionals as well as homeowners in scheduling miticide applications.

*Specified Source(s) of Funding:* NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

**A Survey of the Deep South for Rose Rosette Virus and Its Eriophyid Mite Vector**  
*(Poster Board #118)*

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Across the United States, rose rosette disease has killed thousands of roses. The eriophyid mite, Phyllocoptes fructiphilus, vectors the causal agent, Rose Rosette Virus (RRV), for this disease. Parts of the southeastern United States have remained free of the disease, except for disease introductions that were eradicated. A survey of Alabama, Georgia, and Mississippi plots (n = 204) have revealed the southeastern border of RRV. The presence of RRV in symptomatic samples was confirmed by RT-PCR. Samples were also collected at each plot for detection of eriophyid mites, specifically for P. fructiphilus. These mites were identified through isolation, staining, and light microscopy. Mites were found to be generally distributed throughout the Deep South, however many of these sites contained eriophyid mites that were not *P. fructiphilus*. The reasons for the lack of RRV and low populations of *P. fructiphilus* in the southern regions are unknown.

*Specified Source(s) of Funding:* NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

**Effect of IBA, Number of Leaves per Node, and Number of Nodes per Cutting on the Propagation of Abelia ‘Raspberry Profusion’**  
*(Poster Board #119)*

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*Abelia* is a woody shrub with outstanding landscape characteristics including rapid growth, adaptation to different types of soils, long flowering period, and disease, pest, and drought tolerance. Abelia has a wide variety of flower, sepal, and foliage colors. Despite the diversity of the genus, only a few species and cultivars are available commercially and these are mostly sports of *Abelia xgrandiflora*. Abelia has always been described as an easy to propagate plant by cuttings, but low propagation rates from cuttings has been reported from growers in A. ‘Raspberry Profusion’, a hybrid of *A. Edward Goucher* × *A. chinensis*. Three-node cuttings—with either two leaves per node or three leaves per nodes—were rooted in Fafard® 3B mix and dipped in 1000 or 3000 mg·L⁻¹ powder Indole-3-butryric acid (IBA). Cuttings were placed under mist and evaluated after three weeks. Effect of leaf number, IBA concentration and the interaction between leaf number and IBA concentration were significant for root number and root length. The highest rooting percentage (100%), root number (37.3) and root length (8.7 mm) were obtained with 3000 mg·L⁻¹ IBA on cuttings with three leaves per node. The effect of leaf number per node was also evaluated on one-node and three-node cuttings dipped in 3000 mg·L⁻¹ IBA. Leaf number per node and number of nodes per cutting significantly affected root number (*P < 0.001* and 0.020, respectively) and root length (*P = 0.013* and 0.026, respectively), but no interaction between number of leaves per node and number of nodes per cutting was observed. Root number was higher on three-nodes cuttings (28.2) and in three leaves per node cuttings (31.9). Root length was higher in one-node cuttings (10.3 mm) and in 3 leaves per node cuttings (10.5 mm), but one-node cuttings produced no shoots.
Plant Biotechnology 1 (Poster)

Gramene’s Reference Genomes and Comparative Resource for Horticultural Species
(Poster Board #290)
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Gramene (http://www.gramene.org) is an integrated plant resource for reference genomes and comparative functional analysis in plants. Does your species have a reference assembly, transcript data or genetic variation data for entire populations? If so, these data sets may already be part of Gramene. The current Gramene release contains provides researchers with access to reference assemblies and annotation for 53 genomes (including peach, grape, banana, cocoa, cucumber, sugar beet, common bean, tomato, potato, cassava, yam, and Brassica crops) in a genome browser. In addition, we provide pathways views for 75 plant species including strawberry, orange, chili pepper, peas, and coffee, as well as the species listed above. Have you ever needed to know the function of the gene, and wanted to see the function of the ortholog in rice, maize or Arabidopsis? Does the gene you are working on belong to a large or small gene family. Did the gene family associated with expansion or contractions, in species that are evolutionary close? Is the biochemical pathway you work on conserved in sorghum and soybean? If so, Gramene can help you explore these questions in the Gramene. Gramene provides powerful phylogenetic approaches, including protein-based gene trees with stable IDs and whole-genome DNA alignments, enable traversing between plant species. We provide integrated search capabilities and interactive views to visualize gene features, gene neighborhoods, phylogenetic trees, genetic variation, gene expression profiles, pathways, and cross-references and host curated rice pathways, and uses these curated pathways to generate orthology-based projections for other species. Gramene builds upon Ensembl and Reactome software, and is committed to open accesses and reproducible science based on the FAIR principles, providing both human and machine access to the data.

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Phloem Specific mRNA Isolation Using Translating Ribosome Affinity Purification in Prunus domestica L. (Poster Board #291)
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In plants, the long-distance movement of photosynthates, defense compounds, and signals essential for plant growth and development occurs via the phloem vascular tissue. The phloem is also a key route for the spread of plant pathogens. However, how phloem transport functions at the cellular and molecular levels has been a challenging question to address in part due to the technical difficulty of sampling phloem tissues. The phloem is a pressurized system, and disruption of this pressurized system as is done in many phloem sampling techniques can lead to damage and the introduction of components from neighboring cells. In this study, we adapted a new phloem specific sampling method, called translating ribosome affinity purification (TRAP), for use in plum trees (Prunus domestica L.). An advantage of this approach is that it does not require disruption of the pressurized phloem system prior to mRNA harvesting. Using this method, we identified 1100 genes that were specifically active in the phloem and characterized their activities over the course...
Identification of Citrus Phloem Protoplasts By a Combination of Brightfield and Fluorescent Microscopy (Poster Board #292)

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Phloem-limited diseases, such as citrus greening (Huanglongbing; HLB), are becoming increasingly pervasive, threatening the existence of crops around the world. Studies of phloem diseases are complicated by the inaccessibility of the phloem tissue. Phloem cells are located buried inside the plant body and are interspersed with other cell types. In addition, phloem cells are amongst the smallest cells in a plant kingdom and make up a small percent of the total cell population within a plant. Together these properties create a complex research challenge. Protoplasts should provide an alternative approach to the study of phloem cells in isolation, especially HLB studies, where the causing agent Candidatus Liberibacter asiaticus remains unculturable. However, crucial to this hypothesis is the ability to distinguish sieve elements (SE) and companion cells (CC) within a population of protoplasts. For this purpose, we aimed at developing a system to allow the distinction of SE and CC within a population of protoplasts. For this purpose, we aimed at developing a system to allow the distinction of SE and CC within a population of protoplasts. These properties create a complex research challenge. Protoplasts should provide an alternative approach to the study of phloem cells in isolation, especially HLB studies, where the causing agent Candidatus Liberibacter asiaticus remains unculturable. However, crucial to this hypothesis is the ability to distinguish sieve elements (SE) and companion cells (CC) within a population of protoplasts. For this purpose, we aimed at developing a system to allow the distinction of SE and CC from the remaining cells. We present evidence that using a combination of Neutral Red (acidic compartments), Mito Tracker Green (mitochondria), Hoechst 3342 (nucleus) and chloroplast autofluorescence, allows for the identification of SE and CC protoplasts from citrus leaf tissue. Isolated SE and CC offer an additional approach to advance studies on HLB.

Recombinant Antibodies Targeting Key Bacterial Genes Significantly Reduces Titer of Candidatus Liberibacter asiaticus in ACP-inoculated Carrizo Citrus Rootstock (Poster Board #293)

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The ability to genetically engineer highly resistant plants is an important step toward disease resistance. Current strategies include the expression of bacterial toxins that are targeted to the cytoplasmic membrane, such as the bacterial TolC protein. Bacillus cereus is a model for fungus-specific cytotoxic activity. We developed transgenic plants expressing two bacterial fragments of the Caspase 62 protein family and established a system for the selection of plants with high levels of expression. The Caspase 62 fragments resulted in average reductions in bacterial titers as measured by quantitative PCR analysis. Expression of the antigen-binding fragments resulted in average reductions in bacterial titer by 8.5 Ct (99.8%) for InvA and 6 Ct (99%) for TolC targets. Transgenic populations also showed a much higher proportion of plants with non-detected CLas proteins compared to wild type controls, and these were not included in the statistical analysis. Transgenic plants expressing five additional antigen-binding fragments are currently undergoing ACP inoculation. Transgenic rootstocks are also being grafted with wild type scions for greenhouse and field testing of HLB resistance.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture, Plant-Associated Microbes and Plant-Microbe Interactions Program (2015-67013-23004) and the NSF Division of Integrative Organismal Systems (ISO-1644713)

Metabolic Variations between Grapefruit Cybrid Plants and Their Respect Parentes (Poster Board #294)

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Several grapefruit cybrid plants were developed through the fusion of protoplast from cell suspension of citrus canker highly resistant ‘Meiwa’ kumquat and mesophyll protoplast of three selections of highly susceptible grapefruit. Plants recovered from all three combinations displayed the typical grapefruit phenotype and were all validated to be somatic cybrids. For disease resistance screening, most of the regenerated cybrid clones were evaluated by pressure infiltration inoculation of
**Regeneration of *Cornus florida* (Flowering Dogwood) Plants from Somatic Embryos** (Poster Board #295)
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*Cornus florida* (flowering dogwood) is a small tree native to eastern North America that is commonly planted as an ornamental because of its showy bracts and fall color. Its genome has been sequenced, providing information that could be useful for improving horticultural traits like disease resistance. We investigated somatic embryogenesis (SE) as a potential platform for *C. florida* transformation and gene editing. The induction of SE cultures from immature zygotic embryos of *C. florida* was reported by Trigiano et al. (1989), but plants beyond the first true leaf stage were not recovered. In prior studies in our lab, we identified the *C. florida* genotypes and basal medium (WPM) that gave the best SE response from immature zygotic embryos. In the current study, 160 zygotic embryos from the most responsive parent tree were cultured on WPM containing either an auxin analog or no auxin. Zygotic embryos were exposed to eight media treatments (5 embryos/treatment) at four timepoints (globular to early cotyledon stage). We obtained embryogenic lines from explants exposed to IBA (0.1 mg/L), picloram (0.1 mg/L), 2,4-D (2 mg/L), or no auxin. Overall, the SE response rate was 6.9%, with over half of the embryogenic lines originating, surprisingly, on auxin-free medium. For plant development, somatic embryos were transferred to G-7 boxes containing auxin-free WPM supplemented with 0.25 mg/L activated charcoal. To date, 65.4% of the somatic embryos have germinated and 26.9% have developed beyond the first true leaf stage. The effect of a four-week cold treatment (4 °C) on somatic embryo conversion is being evaluated. Regenerated *C. florida* plants will be transferred to soil and acclimated to greenhouse conditions.

**Elevated Auxin Content in Rootstock Improves the Rooting Performance and Graft Success Rate in Micro-grafting** (Poster Board #297)
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Micro-grafting, an increasingly popular method, involves grafting an aseptic scion onto an in vitro-grown rootstock. Success of micro-grafting is largely dependent on firm contact between rootstock and scion at the graft junction, which will assist the callus formation. Micro-grafting procedures are difficult due to the fact of handling difficulties associated with preserving the delicate graft unions. In this study, we used a root-predominant gene promoter (SbUGT) to drive the expression of a tryptophan-2-mono oxygenase gene (iaaM) from Agrobacterium tumafaciens to increase auxin levels in tobacco rootstock. Our results have showed that over-expression of the iaaM gene in rootstock enhance vascular formation in stem tissues. In our micro-grafting experiments, we have observed that grafting joints using the SbUGT::iaaM rootstock are tighter in junctions than the wild type plant rootstock, and therefore higher success rate of micro-grafting are observed. Also, compared with wild type plant rootstock, we have observed that the stem cuttings of SbUGT::iaaM rootstock plants can root quicker. Furthermore, the expression of iaaM gene in rootstock suppresses their lateral bud releases while growth of scions is not affected. Thus, the SbUGT::iaaM gene may be a useful tool for improving rootstock and subsequently enhancing success rates of micro-grafting for many crop plant species.

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**Molecular Characterization Based on RNA-Seq of Ovaries at Different Developing Stages after Self-pollination in Chinese Chestnut**

*Poster Board #298*

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Chinese chestnut (*Castanea mollissima* Blume.), native to China, has been cultivated as an economically important fruit tree species for thousands of years. Chinese chestnut was found to display late-acting self-incompatibility (LSI), resulting in low fruit bearing percentage and yield. During the LSI process in chestnut, self pollen tubes are hampered in the ovaries instead of styles. To understand molecular character on LSI, transcriptome analysis were conducted on ovaries at four different stages after pollination. A total of 75,554 unigenes were assembled, of which 11,677 unigenes were annotated KOG database covering 26 categories. Genen Ontology (GO) enrichment analysis revealed that many genes involved in metabolic processes, cell part, binding, and catalytic activity. Among them, a number of self-incompatibility-related genes were identified including S-locus-specific glycoprotein S13 precursor, S-locus lectin protein kinase family protein, S-locus-specific glycoprotein S6, calcium-binding protein CML17, and 24 calcium-dependent protein kinase. Compared to 15 days and 30 days after pollination, we screened a total of 285 differentially expressed genes, of which there were 175 genes showed up-regulated and 110 genes down-regulated. Most of the genes participated in catalytic activity, transferase activity, hydrolase activity and nucleotide–sugar metabolic process. The results of study will help fully understand the mechanism of the chestnut LSI and provide useful information for breeding projects.

Specified Source(s) of Funding: The National Natural Science Foundation of China (No.31500554).

**Single Molecule Real Time Transcript Sequencing Unveiled Flowering Regulatory Genes in *Crocus sativus* (Poster Board #299)**

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*Crocus sativus* (saffron) is prized for purple flower that is well-known for producing spice saffron, a most valuable spice with medicinal uses in gynaecopathia and nervous system diseases. Single molecule real time (SMRT) sequencing is a newly developed technology that can generate kilobase-sized sequence reads. Unveiling flowering regulatory genes using SMRT sequencing is important to breed superior cultivars with increase flower numbers, thus resulting in high saffron yield. Two full length transcriptomes of flowering saffron and non-flowering saffron were established using SMRT sequencing separately. The bulb buds, pistils, stamens, petals and leaves of flowering saffron and terminal buds, lateral buds, leaves of non-flowering saffron were used. Meanwhile, higher-accuracy short-read sequencing of terminal and lateral buds of both flowering and non-flowering saffron and small terminal buds (< 6 g) of non-flowering saffron was obtained separately using next generation sequencing (NGS) method. Sixteen SMRT cells were detected, and 22.85 G data was acquired from the PacBio RS II panel. Flowering
and non-flowering saffron had 394,653 and 252,850 high quality full-length transcripts, respectively. A total of 75,351 full-length saffron unigenes were generated. Function annotation showed that 64,562 (85.7%) full-length unigenes were annotated against databases of Cluster of Orthologous Group (COG), Swiss Prot, Non redundant (NR), Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG), and 50,197 coding DNA sequences (CDS) were predicted with an average length of 1081 bp. Alternative splicing (AS) was detected in 72,148 unigenes with 1–217 AS events, among which 42 and 28 AS events existed in flowering and non-flowering saffron gene pool, respectively. In addition to long noncoding RNAs (lncRNAs), single-nucleotide polymorphism (SNP) and simple sequence repeats (SSR) in flowering or non-flowering saffron were obtained. A total of 478 full-length differentially expressed genes between flowering terminal buds and non-flowering terminal buds, 74 genes between flowering lateral buds and non-flowering lateral buds, and 1247 genes between non-flowering small terminal buds and flowering terminal buds was acquired. At least 14 genes were closely related with flowering phenotype using real-time RT-PCR method. Further validation of AS, lncRNAs, SNP, and SSR is needed for flowering and non-flowering saffron.

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**Pomology 2 (Poster)**

**Physiological Response of ‘Honeycrisp’ Apple to Water Deficit** *(Poster Board #425)*

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‘Honeycrisp’ has rapidly increased in production in Washington State over the last 20 years. This cultivar is predisposed to develop bitter pit during storage and produces oversized fruit. Previous work has identified a link between plant water status, fruit size, and bitter pit when crop load was controlled indicating that irrigation could be used as a tool to control fruit size and bitter pit. However, accurate indicators of the physiological water status of ‘Honeycrisp’ need to be developed. Currently, there is little known about how ‘Honeycrisp’ responds to developmentally-timed water limitations. Here, three-year-old ‘Honeycrisp’ were subject to four different irrigation treatments—early season water limitations for 30-day increments. Early water limitations were imposed from 15–45 days after full bloom (DAFB), mid-season water limitations were imposed from 45–75 DAFB, and late-season water limitations were imposed from 75-105 DAFB. The well-watered control was maintained at 80-90% field capacity for the entire season. Physiological measurements included leaf gas exchange, plant water status, stomatal conductance, chlorophyll fluorescence, and leaf reflectance to assess how ‘Honeycrisp’ apple responded to water limitations. At the end of the season, vegetative growth and return bloom was measured to assess the impact of water deficits on growth and productivity. Stomatal conductance was significantly influenced by irrigation deficit. During the early water limitation, stomatal conductance was nearly 40% and 70% lower during middle and late-season water limitations compared to the control. Photosynthesis was approximately 50% lower during all water limited periods compared to the control. Stem water potential was also influenced by deficit irrigation and decreased by 30 to 50% throughout the growing season and were −1.69 MPa, −2.33 MPa, and −2.70 MPa at the end of the early, middle, and late-season water limitations, respectively, compared to −1.23 MPa for the well-watered control. Stem water potential and stomatal conductance were the most responsive during water limitations carried out later during the growing season when temperatures and vapor pressure deficit (VPD) were greater. Early season water limitations have a lower impact on plant response to abiotic stress compared to late-season deficits. Stem water potential, an integrator of soil moisture availability and water demand, and stomatal conductance measurements have the potential to guide in the making of irrigation decisions for fruit size control in ‘Honeycrisp’ apple to better meet market targets and reduce bitter pit.

Specified Source(s) of Funding: Washington State Tree Fruit Research Commission

**Analysis of the Diversity of Flavor Compounds Present in a Collection of Appalachian Cider Apple Varieties** *(Poster Board #426)*

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The cultivation and production of apples has a long history and significant economic impact in West Virginia and the Appalachian region. However, it is notable that total apple production in West Virginia, in particular of table and sauce apples, has declined steadily in the last decades. In contrast, the hard cider industry is growing rapidly nationally as well as in West Virginia and its neighboring states. Although hard ciders were among the most popular and common alcoholic beverages in colonial America, the recent renaissance in craft cider in the United States has led to a dramatic increase in the demand for cider apples, and also revealed a lack of information available to assist cider apple growers and the cider industry. Cider apple varieties are distinctively different from table and sauce apples, typically possessing high polyphenol and/or acid content, as well as other unique flavors. The supply of locally grown cider apples is momentarily quite limited, and the selection of the best blend of cider apple varieties and a sufficient supply of these cider apples is one of the biggest challenges to expanding the cider industry in West Virginia and the Appalachian region, as well as nationally. The
formation and different content of malic acid (responsible for sharpness) and polyphenols (responsible for bitterness), two important sensory characteristics of cider, have been analyzed extensively in an array of cider apple varieties. However, the blend and diversity of flavor compounds, also known as volatile organic compounds, found in apple varieties with potential for hard cider production has not been studied in detail yet. We will present first results from our analysis of flavor compounds in fruits and juice from a collection of cider apple varieties found in the Appalachian region.

**Ecophysiological Adaptation of Malus domestica Borkh ‘Honeycrisp’ Grown under Photoselective Protective Netting**

*(Poster Board #427)*

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Apple production in Washington State (WA) occurs under semi-arid climate characterized by high temperatures and solar radiation. As a result, apple growers in WA are increasingly turning toward photoselective protective netting (PN) to reduce the occurrence of sunburn in apple fruit and reduce tree stress. Previous studies on the ecophysiological response of apple tree under netting have just looked at response under PN on short time scales, but not the entire growing season. Our goal was to understand the ecophysiological response of apple tree under PN over the growing season. The experiment was carried out in a fourth leaf ‘Honeycrisp’ apple commercial orchard on B9 rootstock at Quincy, WA. Measurements were done at 32, 66, 100 and 132 days after full bloom (DAFB). Four treatments were evaluated; an uncovered control, 22% blue, 22% red and 19% pearl PN. Leaf gas exchange measurements were done between 08:00 and 11:00 Pacific Standard Time (PST) before midday depression, whilst leaf spectral reflectance, chlorophyll fluorescence and plant water status were measured between 12:00 and 14:00 PST. Data was analyzed using a two-way analysis of variance with PN treatments and time (DAFB) as factors. There was a significant interaction between PN treatments and time for maximum photochemical efficiency of PSII (Fv/Fm). There were no significant differences between treatments in Fv/Fm at 32, 66 and 100 DAFB. Later in the season at 132 DAFB, Fv/Fm was significantly lower for uncovered trees (0.68) compared to PN treatments and had fallen below the threshold of a healthy leaf (0.79). Quantum photosynthetic yield of PSII had significant effects for PN treatments; it was higher under PN treatments compared to the uncovered control. PN treatment also affected leaf gas exchange. Net carbon assimilation was greater under 22% blue and 19% pearl PN compared to the control. The 22% red PN was not significantly different from the control. Stomatal conductance and leaf transpiration followed the same trend as net carbon assimilation. Midday stem water potentials showed a significant effect for time, it was more negative at 66 and 100 DAFB compared to 32 and 132 DAFB. The reduction in solar radiation stress under protective netting increased light-use efficiency over the growing season. This resulted in improved leaf gas exchange under 22% blue and 19% pearl PN. Protective netting is as a potential tool to alleviate tree stress in apple under high light conditions in WA.

**S-Genotyping in Malus to Determine Cross-compatibility of New Candidate Pollinizers**

*(Poster Board #428)*

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Apple (Malus × domestica Borkh.) exhibits gametophytic self-incompatibility (GSI), which necessitates cross-pollination to achieve desired fruit and seed set in commercial orchards. The GSI mechanism is controlled by the multi-allelic S locus, which harbors genes encoding pollen- and pistil-part determinants. In the pistil, S-RNases are expressed and are cytotoxic to incompatible pollen carrying S alleles identical to the seed parent, whereas pollen carrying S alleles differing from a seed parent are able to detoxify the S-RNases and inhibit degradation. Because the apple industry relies on consistent pollen viability it is imperative that pollinizer varieties produce cross-compatible pollen. In this study, the S-RNase gene was used as a target to determine the S-genotypes of over 30 crabapple varieties currently under evaluation for use as apple pollinizers. Polymerase chain reaction (PCR) methods using allele-specific primers in combination with consensus PCR and restriction fragment length polymorphism (RFLP) methods were used to determine S-haplotypes. Novel S-RNase sequences were characterized and submitted to the National Center for Biotechnology Information GenBank database, and molecular identification methods were developed. The results of this work serve to inform pollinizer-cultivar compatibility, and the methods developed aim to supplement future S-genotyping work.

**Utilizing UV-Vis Spectroscopy to Estimate Pollen Density in Suspensions**

*(Poster Board #429)*

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Pollen density in suspensions can be estimated using UV-Vis spectroscopy. However, this method is limited by the Beer-Lambert law and is limited to low concentrations of pollen. In this study, we developed a new approach to estimate pollen density by utilizing the Beer-Lambert law for a known concentration of pollen, and then applying this method to unknown concentrations. The results of this work serve to inform pollinizer-cultivar compatibility, and the methods developed aim to supplement future S-genotyping work.
In vitro pollen germination and viability assays are commonly used to assess pollen quality. Two of the most frequently used germination methods are the hanging drop technique and the use of agar plates. Different authors have reported a significant effect of pollen density on pollen germination. Therefore, the pollen concentration must be standardized between different samples when performing germination tests. A fast, reliable and possibly non-destructive method is needed, since pollen grains can start germination as soon as five minutes after being mixed with germination media. Stored pollen (−20 °C) from five apple cultivars (Gala, Granny Smith, Honeycrisp, Red Delicious, and Rome Beauty) were used for this experiment. A stock solution for each cultivar was created by suspending 0.5 g of pollen in 20 mL pollen germination media (10 g·L⁻¹ sucrose, 40 mg·L⁻¹ boric acid). A serial dilution with three replicates for each cultivar stock was created (0, 25, 50, 75, 100 %). The absorbance (optical density) between 400 and 700 nm (1 nm intervals, scan speed 600 nm/minute) was measured using a spectrophotometer (Cary 60 UV-Vis, Agilent Technologies). A hemocytometer was used to count the number of pollen grains of the dilutions. The cultivar specific regression models showed a coefficient of determination of 0.98, 0.98, 0.96, 0.98, 0.98 for ‘Gala’, ‘Granny Smith’, ‘Honeycrisp’, ‘Red Delicious’, and ‘Rome Beauty’, respectively. The R² value decreased slightly when using a general regression model that includes all five cultivars (R² = 0.89). The decreases could be explained by variations in pollen grain size between cultivars. Every tested wavelength was suitable to estimate the optical density of pollen solutions. There are two applications for the described method. Optical Density (OD 400–700) can be used to adjust pollen concentration in suspension. Using a spectrophotometer is a fast, reliable and non-destructive approach that can be integrated with in vitro germination and viability assays. Furthermore, this method would allow for estimation of the pollen yield of different pollinizers. A standard method for quantifying pollen yield is the use of a hemocytometer. However, this method can be time consuming when screening large populations. Cultivar specific OD models are necessary when the variation in pollen grain size becomes too large.

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Air Root Pruning Containers Alter Root Architecture and Increase Canopy and Root Growth of Apple Trees Compared to Field Grown Liners (Poster Board #430)

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Trees account for the majority of expenses when establishing high-density plantings. The vast proportion of nursery trees are produced in the field and shipped bare-root. These trees are prone to transplant-shock and may require additional time to fill orchard space. The objectives of this project were to: 1) compare two nursery production systems (air root-pruning containers and field-produced liners [i.e., bare-root trees]) on the growth and development of above-ground and below-ground organs of apple trees during the formative ‘nursery’ year; and 2) correlate these parameters with canopy growth and fruiting during the establishment years in the orchard. We hypothesized that container-produced trees would possess higher-quality root systems that mitigate transplant-shock and result in rapid canopy infill to expedite orchard return on investment. This experiment was conducted in 2017 at the Michigan State University Horticulture Teaching and Research Center. Three apple cultivars ‘Gala’, ‘Fuji’, and ‘Honeycrisp’ were bench-grafted to M9 Nic29 rootstock and divided into two production systems: Ellepot containers and field liners. Entire plants were carefully harvested from each production system several times throughout the season. Leaf area, average leaf size, trunk cross-sectional and total above-ground dry matter were quantified. Whole root systems were scanned to determine root growth and architecture (size classes) then dried (dry matter). Growth of Ellepot-produced trees was more uniform and total leaf area, average leaf size, and seasonal above ground dry matter were significantly (P < 0.05) greater than field grown trees, irrespective of scion. Root morphology differed drastically between the two systems. Ellepot-produced trees had markedly higher fine root production and greater root length density compared to field liners. In spring 2018, container and bare-root trees were established in an orchard. Root and canopy development are being monitored throughout the season.

Effects of Leader Bagging, 6-Benzyladenine (6-BA), and GA₄₋₇ Plus 6-BA on Lateral Branching of 3rd Leaf ‘Gala’ Apple (Poster Board #431)

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Inadequate lateral branch development can have negative consequences on apple orchard productivity and profitability, particularly in high-density orchard systems. While plant growth regulator applications are generally utilized to increase lateral branching on leaders of young apple trees (1st and 2nd leaf), inconsistent responses were observed on older trees in the southeastern United States. In 2017, an experiment was initiated to identify effective leader management strategies on 3rd leaf ‘Gala’/‘M.9’ apple trees at a commercial orchard in Edneyville, NC. Ninety-six uniform trees were selected and treatments were assigned to single-tree plots in a completely randomized design. The experiment had a factorial treatment structure with eight replicates. Effects of leader bagging (bagged or unbagged), 6-benzyladenine (6-BA; applied at green tip, silver tip, or untreated), and 6-BA+GA₄₋₇ (treated or untreated) on lateral branch development of one-year-old leaders were evaluated. Leader bagging occurred at the silver tip stage of bud development. Bagged leaders were enclosed in a 96.5 × 15.2 cm section of

An asterisk (*) following a name indicates the presenting author.
4-mil polyethylene tubing and secured using clothespins. Bags were removed once lateral branches were ~3 cm long. Where appropriate, 6-BA was applied at 500 mg·L⁻¹ and 6-BA + GA₄+7 was applied at 250 mg·L⁻¹ + 0.2% (v:v) non-ionic surfactant when lateral branches were 3–5 cm long. During dormancy, the number and length of lateral branches on the treated section of leader and terminal shoot length was determined. Analysis of variance was used to test main effects and interactions. When compared to unbagged trees, leader bagging increased lateral branch number (17%), average branch length (25%), and total linear bearing surface (43%) of the treated section of leader. Application of 6-BA + GA₄+7 increased average branch length (17%), but had no effect on branch number or total linear bearing surface. Measured responses were not influenced by 6-BA or interactions between factors. Terminal shoot length was not influenced by any factor. Leader bagging was effective in increasing lateral branch number, length, and total linear bearing surface, but this procedure was labor intensive. Application of 6-BA did not influence lateral branch number or length at the application timings evaluated, but 6-BA + GA₄+7 increased average branch length. Future efforts will focus on productivity and profitability of leader management strategies and characterizing the localized environment of bagged leaders.

**Use a Natural Mutant Yeast Strain and Transcriptomics Analysis Reveal Genes That Influence Occurrence of Hydrogen Sulfite in Cider Fermentation under Different Levels of Yeast Assimilable Nitrogen** *(Poster Board #433)*

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Apple (*Malus × domestica* Borkh.) juice typically contains low concentrations of yeast assimilable nitrogen (YAN). During fermentation, this can cause yeast (*Saccharomyces cerevisiae*) cells to produce the sulfur containing amino acids, methionine and cysteine, a reaction that reduces sulfate to hydrogen sulfide (H₂S). When H₂S is produced in excess, it is considered a sensory fault as this compound is associated with a “rotten egg” smell. The goal of this research was to determine the effect of YAN concentration, as adjusted with diammonium phosphate to low (86 mg·L⁻¹), intermediate (208 mg·L⁻¹), and high (433 mg·L⁻¹) concentrations, on yeast H₂S production and yeast gene expression during apple cider fermentation. Each YAN treatment was fermented in quadruplicate with UCD932 (a strain with a natural mutation in the *MET10* gene and therefore produces no H₂S) and UCD522 (a commercially available strain known to produce relatively high H₂S concentrations). The same base apple juice was used for all treatments and all other fermentation conditions [e.g., temperature, physical agitation, and potassium metabisulphite (160 mg·L⁻¹) additions] were kept constant. All fermentations fully metabolized the available sugar. For both UCD932 and UCD522, the intermediate YAN concentration resulted in faster fermentation rates than the low or high YAN concentrations. Under the intermediate YAN concentration, the fermentation rate of UCD932 was 34% greater than that of UCD522. The fermentation rates showed the maximum difference at a YAN concentration of 208 mg·L⁻¹. The fermentation rates showed the minimum difference at 86 mg·L⁻¹. The fermentation rates of UCD522 and UCD932 were similar. At these three different YAN concentrations, there were significant differences in H₂S production with UCD522. Under the medium YAN concentration, UCD522 produced 2 and 6 times greater H₂S than those under the low and high YAN concentration, respectively. Total RNA was extracted from yeast cells sampled at the initial phase of fermentation and at the peak of H₂S production using a hot phenol method. RNA samples were prepared as biological triplicates and for RNA-Seq Library sequencing using standard Illumina protocols. Further data analyses will include RNA-Seq, HPLC, and microarrays, as well as bioinformatics data analyses (Tophat v2.0.8b, PCA, MFA). Our results will identify the yeast genes associated with H₂S production in cider fermentation and ultimately reduce the production of ciders with a rotten egg smell.

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**Cost-benefit Analysis of DNA-informed Apple Breeding** *(Poster Board #435)*

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DNA-informed breeding techniques allow breeders to more quickly select and breed crops with desired traits and genes as compared to conventional breeding methods. Incorporation of this technology requires additional costs for reagents, machinery, and labor. In order to elucidate cost-effectiveness of DNA-informed breeding in perennial crops with multi-year generations; we conducted a cost-benefit analysis examining incorporation of marker-assisted selection (MAS), a type of DNA-informed breeding, in an apple breeding program. Annual production costs for a Midwest apple breeding program were used to construct a simulation using itemized costs and per unit costs for each procedure in the program. Simulations using these costs compared MAS at the greenhouse growth stage with cull rates of high (50%), medium (25%), and low (10%) to conventional
breeding methods without MAS. The break-even point where cost-savings associated with MAS equals the additional costs incurred was then calculated. Additional sensitivity analyses were conducted exploring decreases in MAS laboratory costs, seedling maintenance costs, and seedling evaluation costs. These results have important implications for breeding programs of perennial crops considering incorporation of DNA-informed breeding.

**Establishing a Cider Apple Orchard for Mechanized Management (Poster Board #436)**

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Washington State, like many other states, has been dealing with labor shortages across the agricultural sector for many years. Short-term strategies for managing labor shortages have included adjusting growing practices, increasing off-season activities, and increasing wages. Long-term strategies have included shifting to less labor-intensive cropping systems and increasing investment in mechanization. For cider apple production, mechanization of pruning, thinning, and harvest requires a high-density orchard training system that is characterized by a planar canopy that is about 2 feet in width, and includes long continuous rows that are suitable for equipment. We have developed a guide to provide commercial cider apple growers with orchard management options that will reduce the need for hand labor. Specific objectives are to establish a high-density fruiting wall that will allow for mechanized pruning, thinning, and harvesting, and to mechanically manage the fruiting wall such that fruit yield and quality are optimized. The first objective will be achieved by methodically training and pruning in response to the growth and bearing habit of the cultivar selected for production. The second objective will be achieved by focusing wall maintenance on the removal of wood that is damaged, shading, diseased, or dead. Equipment that will be used is dependent on the scale of the orchard and available financial resources, and includes hand-held pruners, loppers, and a mechanical hedger. It is important to note that for small-scale growers who may find mechanical harvest equipment unaffordable, mechanized thinning and pruning followed by hand harvest will still significantly reduce labor needs. As discussed in the guide, the experiences at Washington State University Mount Vernon Northwestern Washington Research and Extension Center where we have established such an orchard may be especially applicable for small-scale growers, as a lower cost hand-held hedger was used for mechanical pruning rather than a tractor-mounted hedger.

**Root Growth and Rhizosphere Dynamics (Poster)**

**A Novel Sensor and Technique to Quantify Root Respiration (Poster Board #331)**

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Oxygen consumption, measured by galvanic cell oxygen sensors (Apogee Instruments, Logan UT) connected to an automated data acquisition system were used to quantify postharvest root respiration in multiple closed chambers. Individual sensors were mounted in sealed glass jars (240 cm$^3$) containing roots and media harvested from plants grown in “128-plug trays” (individual cell volume = 22 cm$^3$). Separate sensors were mounted in jars containing media only (empty cells adjacent to those with plants) to quantify background microbial respiration. After stabilizing for 15 minutes, oxygen depletion was measured from 15–30 minutes (data collected every second) after closure and the root respiration rate was calculated from linear regression. Respiration per unit mass was calculated by dividing CO$_2$ evolution rate by root fresh and dry mass (after washing media from roots). This technique was used to quantify differences between ornamental and vegetable species root respiration rate, and in a separate experiment, conduct temperature response curves on several tomato cultivars that vary in heat tolerance. The benefits and limitations of this technique for rapid quantification of root respiration rate resulting from our experimentation will be discussed.

*Specified Source(s) of Funding:* USDA-ARS, MN-DRIVE

**Variation in Root Respiration Rate among Herbaceous Ornamental Plant Species (Poster Board #332)**

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Seedlings were grown at the same time in a “288 plug trays” (individual cell volume = 40 cm$^3$) in a soilless media until plants unfolded 3–10 leaves (species specific). Thirty root masses (including media) from each species were harvested (separated from the stem) and five masses were placed in each of six sealed (metal top) glass jars (240 cm$^3$ volume) with an oxygen sensor mounted vertically through the top of each jar. A separate sensor was mounted in a jar with five media-only masses (taken from empty cells adjacent to plants) to quantify potential background microbial respiration in each cell. After closing jars, and a 1-h
stabilization period, absolute oxygen concentration was measured for two additional hours (data collected every 10 sec) and root respiration rate was calculated from a linear regression fit to kPa oxygen depletion over time. Respiration rate varied from 0.0000239 to 0.0000126 kPa, 10 seconds per gram fresh weight for *Angelonia* and *Coles*, respectively. Respiration rate varied from 0 to 0.000340 to 0.000184 kPa, 10 seconds per gram dry weight for *Petunia* and *Tagetes*, respectively.

*Specified Source(s) of Funding:* USDA-ARS; FRA; Minnesota Agriculture Experiment Station

**Using a Split-root Hydroponic System to Study Rhizosphere Acidification in Southern Highbush Blueberry** *(Poster Board #333)*

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Hydroponic growing systems are an effective tool for studying plant nutritional physiology because nutrient concentrations can be easily controlled. Typically, these studies entail exposing the entire root system to the same nutrient solution. This design fails to account for soil heterogeneity. Moreover, it poses a challenge for plant nutritional physiology experiments where local and systemic responses need to be isolated. Previous studies suggest that southern highbush blueberry (SHB, *Vaccinium corymbosum* interspecific hybrids) and other *Vaccinium* spp. do not acidify their rhizosphere. However, these studies used single-reservoir hydroponic systems, which confound direct and nutrient uptake-dependent rhizosphere acidification. We designed a split-root hydroponic system to distinguish between nutrient uptake-dependent rhizosphere acidification (local response) and direct, H+-ATPase-mediated rhizosphere acidification (systemic response) in hydroponically grown SHB. One-year-old rooted cuttings of ‘Emerald’ SHB were transplanted to a hydroponic growth system where each half of the root system was in a different reservoir. One reservoir was supplied with a buffered, complete nutrient solution containing 2.5 mM NH4+. The other reservoir was supplied with a non-buffered nutrient solution containing either 2.5 mM NH4+ (treatment NH4+/NH4+) or no nitrogen (treatment NH4+ /None). All nutrient solutions were continuously aerated. Fresh nutrient solutions were supplied every 7 days. Hydroponic solution pH was measured periodically. Root relative electrolyte leakage (REL), and tissue N content were measured destructively after 35 days of treatment. Plants in both treatments exhibited similar, adequate leaf N levels (*P > 0.05*) and similar root REL (*P > 0.05*), suggesting that the split root design and treatments did not cause N deficiency or root stress. Both NH4+ uptake-dependent rhizosphere acidification and direct rhizosphere acidification were observed. NH4+ uptake-dependent rhizosphere acidification occurred at a higher rate than direct rhizosphere acidification. These findings suggest that SHB exhibits both systemic and localized rhizosphere acidification.

Using a split-root hydroponic growth system helped distinguish between these two responses.

*Specified Source(s) of Funding:* Thad Cochran Southern Horticultural Laboratory, U.S. Department of Agriculture Agricultural Research Service, under award number 58–6062–5-004

**Comparing Saturation and Particle Density Methods to Derive Substrate Porosity** *(Poster Board #334)*

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The total porosity of substrate components can be derived from indirect measurements such as the North Carolina State University (NCSU) Porometer Method (PM), a saturation method, or calculated from its bulk volume divided by its particle density (ρs). In order to calculate substrate total porosity from ρs, coir, peat, pine bark, perlite, and wood fiber components were analyzed using a helium gas pycnometer. Porometer Method data was collected from the NCSU Horticultural Substrates Lab’s database on single component substrates and compared to the calculated total porosity derived from ρs. The PM’s measured total porosities were consistently lower than the derived total porosity determined by ρs. However, it was observed that the initial moisture content of the substrate prior to being subjected to the PM affected the agreement between the two methods. Assuming the ρs derived total porosity provides the true value, the optimal moisture content to achieve the most accurate results from the PM could be determined for each material.

**Total Porosity of Horticultural Substrates Derived from Particle Density** *(Poster Board #335)*

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The particle density (ρs) of a porous medium represents one of its basic physical properties. The ρs of coir, peat, perlite, pine bark, and wood fiber were analyzed by gas pycnometer using helium (He), nitrogen (N), and purified air. Gas significantly affected the measured ρs of organic substrate components. For example, gas containing high concentrations of N resulted in a lower pine bark ρs, 1.08 g/cm³, than He, 1.20 g/cm³. The measured ρs of wood, peat, and coir with He were 1.40 g/cm³, 1.44 g/cm³, and 1.49 g/cm³, respectively. Grinding each component increased the measured ρs for perlite and pine bark. An increase in ρs after grinding suggest that inaccessible voids were present within perlite and pine bark particles. For both perlite and pine bark, the effective ρs could be correlated to its particle size dis-
Poster Presentations

Utilizing Image Analysis to Obtain Particle Size Distributions of Substrate Components
(Poster Board #336)

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Particle size analysis is conducted to better understand the physical characteristics of a material or to ensure a product remains within a predetermined range of sizes for quality control. Previously in substrate research, particle size analysis has been conducted by sieving as the principles of sieving are easy to understand and the equipment is relatively cheap. However, sieving provides very little data about the shape characteristics of the material. Additionally, the equipment would be difficult to incorporate into a streamlined production system. Image analysis is capable of obtaining similar particle size distribution data and the equipment could be easily incorporated into a streamlined production system. Substrates were analyzed using a computerized particle analyzer (CPA) to explore the potential of image analysis for substrate characterization. Tyler’s CPA analyzes each individual particle greater than 33 microns as the particle passes between a light source and camera. Each particle is instantly analyzed according to any one of many operator-selected parameters, such as equivalent diameter, minimum Feret, maximum Feret, length, skeletal length, or geodetic length. The thorough analysis of the CPA includes distributions of a sample’s particle count, length, area, volume, or length to width ratio. Although the equipment was hindered by touching or dust-sized particles, image analysis provides a plethora of information to characterize a material beyond that of sieving’s capabilities.

Infection By Reniform Nematode (Rotylenchulus reniformis) Alters Root Growth, Architecture,
and Gene Expression in Upland Cotton (Gossypium hirsutum) (Poster Board #337)

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Reniform nematode (Rotylenchulus reniformis, RN) is a sedentary plant-parasitic nematode that infects over 300 species from numerous plant families in tropical, subtropical, and warm-temperate regions. Among its hosts are multiple economically-important crops, including pineapple, soybean, and cotton. Belowground parasitism by RN involves anatomical and metabolic changes in root pericycle cells, the same cells from which lateral roots emerge. We investigated the effect of RN parasitism on root growth, architecture and histology in upland cotton (Gossypium hirsutum) and documented the expression of multiple genes related to lateral root development and auxin dynamics in parasitized roots. Nematode-induced changes in root growth were measured in three plant culture systems: split-root pots, foam cups, and germination pouches. Gene expression of infected and uninfected roots was measured using Illumina-based RNA sequencing, followed by Trinity de novo transcriptome assembly and transcript quantification with rsem and DESeq2. At 3 days after inoculation (DAI), RNs had penetrated cotton roots intracellularly; some nematodes had arrived at the endodermis. At this stage, the pericycle cells surrounding the nematode head were not visibly modified. By 9 DAI, expanding feeding sites (syncytia) were clearly visible as regions of hypertrophied, interconnected pericycle cells filled with dense cytoplasm, enlarged nuclei and nucleoli, and an increased number and size of organelles. Across multiple plant culture systems, nematode parasitism increased total root length, weight, branching, and fractal dimension. Simultaneously, the expression of multiple genes associated with lateral root development and with auxin metabolism, transport, and response were altered in parasitized roots. Of particular note was the up-regulation at 3 DAI of Lateral Root Primordium 1, an auxin-regulated transcription factor whose Arabidopsis homolog is expressed in developing lateral root primordia. Also strongly induced in early parasitism were genes encoding the auxin biosynthetic enzyme YUCCA10 and an auxin polar transporter from the ABC family. Later stages of parasitism were characterized by the differential expression of additional auxin transporters, auxin response factors, and lateral root-associated genes. The increased production of lateral roots in parasitized plants may result from nematode manipulation of the plant’s own hormonal pathways. Alternately it may reflect increased allocation of carbon to root growth in response to the strong sink produced by nematode feeding. A larger root system may ultimately benefit the parasite by increasing the root surface area available for feeding by its offspring.

Specified Source(s) of Funding: Cotton, Inc.

Temperate Tree Nut Crops (Poster)

Visual Injury of Selected Fruit and Nut Plants to Driftable Fractions of Dicamba, 2-4D, and
Glyphosate (Poster Board #409)

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The reformulation of low-drift dicamba (Xtendimax + Vapor Guard Technology®) and 2,4-D (Enlist One + Colex-D Technology®) and their subsequent use alone or in combination with glyphosate on herbicide-resistant row crops have resulted in numerous cases of off-target movement and injury to horticultural plants. A study was conducted to evaluate the sensitivity of one-year-old apple, elderberry, grape, peach, pecan, eastern black walnut, raspberry, and strawberry plants following the application of three driftable fractions (1/2X, 1/20X, and 1/200X) of the labeled rate of dicamba (0.56 kg·ha⁻¹·ae) or 2,4-D choline (1.09 kg·ha⁻¹·ae), with or without glyphosate (1.12 kg·ha⁻¹·ae). By 28 days after treatment, dicamba-treated plants had symptoms of chlorosis and inward cupping of young foliage and 2,4-D-treated plants generally expressed symptoms of epinasty or leaf distortion. At the 1/2X rate, visual injury was more severe for apple, peach, pecan, and elderberry plants treated with dicamba compared with 2,4-D. In contrast, injury to walnut and grape plants treated with 2,4-D was more severe than that of dicamba at the 1/2X rate, but raspberry and strawberry injury was similar for both herbicides. The addition of glyphosate to either herbicide increased injury of all plants except grape.

**Pistachio Precocity: Choose a Cultivar That Makes Money Sooner** *(Poster Board #410)*

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Compared to many fruit and nut crops grown in California, pistachio (*Pistacia vera* L.) is relatively slow to provide an economic return to growers. Typically, the first harvest does not occur in the San Joaquin Valley of California until the trees are five or six years old. Precocity, the ability of a cultivar or variety to produce nuts in a reduced time interval after planting, is a desirable characteristic in that producers can begin recouping their initial investment earlier. However, many of the cultivars grown in California, have not been compared in replicated and randomized scientific trials with the objective of evaluating differences in precocity, bloom timing, and nut quality characteristics. The objective of this research was to address this deficiency by comparing cultivars that are currently grown or were grown in California and variety selections that appear to have commercial potential from the University of California breeding program or from farmer collections. In this single trial, planted in 2010 on clonal rootstock and located within the pistachio growing area of the southern San Joaquin Valley, we compared the following cultivars: Golden Hills, Joley, Kaleghouchi, Kerman, Lost Hills, Pete 1, Red Aleppo, Ruehle, and Sirora; and the varieties KB25-78, KA22-80 and Velez. Differences were found in precocity, bloom timing, nut weight, shell splitting and other nut quality characteristics, which should be of interest to commercial pistachio producers, processors and breeders.

**Determining the Effect of Acadian LSC Seaweed Extract, Maxcel PGR, and Low-biuret Urea on Pistachio Inflorescence Bud Abscission** *(Poster Board #411)*

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This trial examined the potential of *Ascophyllum nodosum* based biostimulants, produced by Acadian Seaplants LLC, the currently registered growth regulator, MaxCel® (6-benzyladenine (6BA) 1.9% AI), and low-biuret urea (Total Nitrogen Analysis 46.0% minimum), to mitigate floral bud abscission in pistachios, the visible mechanism of alternate bearing. The Acadian products are formulated to alleviate alternate bearing by increasing shoot nitrogen levels to enhance photosynthesis and carbohydrate status of the shoot. MaxCel is a growth regulator used to increase bud sink strength, and low-biuret urea is used as a nitrogen fertil-izer. Eight different treatment combinations were applied to 8 replicate rows over two growing seasons. Treatment applications at 1085 and 1380 accumulated temperature units were selected to correlate with the initiation and midpoint of embryo growth respectively. Average percent bud abscission ranged from 86 to 95% across all treatments with no significant differences in abscission or yield between treatments at α = 0.05.

**Specified Source(s) of Funding:** California Pistachio Research Board and the University of California
Performance of Seven Pecan Cultivars in South Georgia (Poster Board #412)

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Seven pecan (Carya illinoinensis) genotypes were evaluated over 15 years in a yield trial at Tifton, Georgia, USA. Genotypes included five cultivars; Cherokee, Excel, McMillan, Nacono, and Zinner, and ‘Desirable’ and ‘Stuart’ as check cultivars. Actual yields were measured for each tree in the test and a 50 nut sample was taken to determine nut quality. Trees were evaluated for leaf and nut scab infection (Venturia effusa) and black aphid (Melanocallis caryaefoliae) damage. Significant differences were found for yield with all cultivars performing better than ‘Desirable’. Cultivars also varied widely in alternate bearing intensity. ‘McMillan’ and ‘Excel’ had exceptional pest resistance, but mediocre nut quality. ‘Zinner’ produced consistent yields of high-quality nuts and had adequate pest resistance for this region. ‘Nacono’ and ‘Cherry’ both produced large high-quality nuts and had moderately irregular bearing. ‘Stuart’ is an older cultivar that produces a low-quality nut and is no longer recommended to be planted. ‘Desirable’ is the most common cultivar in Georgia, but extreme scab susceptibility make it a poor choice for new plantings.

Specified Source(s) of Funding: Georgia Agricultural Commodity Commission for Pecan

Long-term Observation of Resistance Sources to Eastern Filbert Blight in New Jersey (Poster Board #414)

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Three hundred and eighty-three clonal accessions of Corylus were assessed for their response when exposed to eastern filbert blight (EFB, Anisogramma anomala) in New Jersey. The plants were deemed resistant or tolerant to EFB in previous studies and acquired from the U.S. Department of Agriculture Agricultural Research Service National Clonal Germplasm Repository, the University of Nebraska-Lincoln, the National Arbor Day Foundation, and Oregon State University. Further, clonal accessions derived from multiple seed introductions from across the native range of C. avellana in Europe and the Caucasus were included. The trees were planted in the field from 2004 to 2012 and subsequently exposed to EFB on a yearly basis. This study expands upon earlier work published in 2012 by examining disease progression over a longer time-period using additional genotypes. In January 2018, all trees were evaluated for presence of EFB. It was found that 207 of 383 accessions remained free of the disease. The 148 accessions with EFB present had their cankers measured and proportion of diseased wood calculated. Most noteworthy, ‘Ratoli’, a Spanish cultivar that carries a dominant R-gene, and all six of its selected offspring remained free of EFB across the span of this study. Further, all eight offspring of Yoder #5, a C. americana × C. avellana hybrid, also remained free of EFB, as did OSU 541.147, a C. americana × C. avellana hybrid related to C. americana ‘Rush’. Fifty-three of 65 new germplasm introductions selected at Rutgers and deemed resistant in earlier studies still remain free of EFB. In contrast, most accessions protected by the ‘Gasaway’ R-gene deteriorated with time. For instance, all ‘Zimmerman’ trees planted in 2005 were free of disease in 2012, whereas today five of the remaining six trees are infected. In addition, ‘Jeferson’ had its proportion of diseased wood increase from 4% to 31% and expresses larger individual cankers than recorded in 2012. Similarly, EFB increased on ‘Yamhill’ from 2% to 20%. Overall, most accessions from Oregon remained at least tolerant in New Jersey (proportion of diseased wood less than 25%), but only about a third remained free of EFB. Fortunately, more than 80% of the of the new introductions and nearly all C. fargesii, C. chinesis, C. heterophylla, and C. americana accessions continued to remain free of EFB. Generally, these results convey that a wide diversity of Corylus germplasm exists to support breeding efforts to combat this devastating disease.
Inadequate Chill Influences Carbohydrate Resources and Flower Development in Pistachio (Pistacia vera L.) (Poster Board #415)

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Premature flowers, uneven bud break and poor bloom synchrony were observed in pistachio due to the lack of chill in warm winters. Previous research demonstrated warm temperatures (> 45°F) during dormancy increased shoot respiration and consumption of carbohydrates. To understand this better, we compared the flower bud development and carbohydrate levels of 'Kerman' and 'Peters' pistachio trees under low (400 chilling hours) and high (800 chilling hours) winter temperatures. The buds, and shoot sections that 5cm beneath the individual buds were collected biweekly from February through April in 2016 and 2017. The soluble sugar and starch content of the shoot’s phloem and xylem were tested. Results demonstrated that with low chill both male and female flowers bloomed more slowly than flowers that experienced high chill. Consistently, the carbohydrate contents of shoots receiving low chill were significantly lower than the carbohydrate contents of shoots that had received more chilling. At bloom flower buds with high chill had a higher sugar content and produced better bloom than buds with low chill. This data suggests warmer temperatures promoted respiration that exhausted the shoots’ carbohydrates that support bloom.

Specified Source(s) of Funding: California Pistachio Research Board

Computer Applications in Horticulture (Poster)

Ifarmer’s Bookshelf—High Technology in Agriculture (Poster Board #338)

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The Farmer’s Bookshelf information system was created in 1987 on a Macintosh computer using the application software HyperCard. Initially covering fruit crops in Hawaii, it was later expanded to other crops and cost of analysis spreadsheets. A version was created to run on PC (IBM compatible) computers using the application software Spinnaker PLUS. The Farmer’s Bookshelf was later modified to run on the World Wide Web. Recently, an extension agent in Hawaii expressed interest in updating the Farmer’s Bookshelf. It was decided that the updating and management of this information system would be taken over by this agent and another extension agent. We then saw the potential for creating another version of the Farmer’s Bookshelf that went beyond just crops. The iFarmer’s Bookshelf is a mobile version of the Farmer’s Bookshelf. Rather than crops, it covers a diverse range of topics related to high technology in agriculture. We used Google Sites to develop the iFarmer’s Bookshelf. Google Sites was chosen because the iFarmer’s Bookshelf could be stored on the University of Hawaii server and the ease of having the iFarmer’s Bookshelf formatted especially for use on mobile devices. Unlike the original Farmer’s Bookshelf, which covered various crops, the iFarmer’s Bookshelf covers various topics related to high technology in agriculture. These topics were chosen from the latest technological fields in agriculture. The topics and pages include What’s New Today, Things to Do, Innovative Agriculture, High Technology, Hydroponics, Unmanned Aerial Vehicles, Precision Agriculture, Space Farming, Robotics, Nanotechnology, Augmented Reality, Artificial Intelligence, and Science Conferences. RSS feeds and news aggregators were used to find and retrieve cutting-edge information. In conclusion, the iFarmer’s Bookshelf goes beyond the original Farmer’s Bookshelf by keeping users up-to-date with innovative high technology in the ever-changing fields of agriculture.

Specified Source(s) of Funding: Smith Lever Funds

Remote Detection of Growth Dynamics in Red Lettuce (Poster Board #339)

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Chlorophyll fluorescence (ChlF) is used as a tool to measure photochemical efficiency, health status, stress and photosynthesis in plants. Remote tracking of the overall health and growth status of plants by ChlF detection can reduce energy requirements for growers by allowing light output to be synchronized with plant needs. However, current ChlF measurement systems are expensive, labor intensive, and invasive, making them impractical for use in controlled environment agriculture (CEA). Here, real time growth dynamics of red lettuce was monitored using a new, custom-made, cost effective and simple to operate ChlF detector. The device remotely measures canopy ChlF in the light-adapted state immediately after an excitation pulse from a blue (470 nm) LED excitation light. The LESA detector requires no physical contact with plants and automated ChlF measurements are taken at user-defined intervals throughout the growth period and stored in a cloud database for easy manual or automated access and analysis. The ChlF system successfully provided automated, real time tracking of growth dynamics in red lettuce over a 17-day period with no observed effect on plant growth. The rate of change in the ChlF signal was closely correlated with changes in biomass and plant area in the growing plants.
Polymer regression modeling from observed values enabled biomass and plant area to be estimated from observed ChlF. Relative growth rate (RGR) and leaf area ratio (LAR) calculated from these estimates were within 10% of those calculated from observed values, demonstrating that ChlF measured by this device can serve as a reasonably-accurate proxy for physical growth dynamics in red lettuce. To our knowledge, the chlorophyll fluorescence detection system described here is the first device of its kind designed for the purpose of remotely monitoring crop health and growth dynamics in real time.

Specified Source(s) of Funding: NSF

Dynamic Lighting Control Programs: Intensity Modulation versus Binary Control

(Poster Board #340)
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Electricity for supplemental lighting is a major cost of year-round crop production, so increasing efficacy of lighting is of primary concern to growers. Market opportunities may support projects with high energy use intensity, which again highlights the need for energy efficient technologies. In greenhouse production, where electric light is supplemented against a broad-spectrum background, only supplemental wavelengths with the highest photosynthetic efficiency justify the cost of electric lighting, and plant growth is largely correlated to the overall quantity of light received. Intensity of photosynthetically active radiation (PAR) is expressed in quantum units, or photosynthetic photon flux density (PPFD), which is the number of photons occurring per square meter per second (µmol·m⁻²·s⁻¹). The daily light integral (DLI) (mol·m⁻²·d⁻¹) is the sum of PPFD occurring in a day and is commonly used to express crop specific light requirements. Any reduction in the quantity of supplemental light, while maintaining minimum instantaneous and integrated lighting targets, will coincide with reduced electricity costs for growers. Modulating the intensity of supplemental light can be accomplished at high temporal resolution using computational control mechanisms and LED fixtures. The current research compares the efficiency of two lighting control strategies, intensity modulation and binary off/on. Intensity modulation varies supplemental PPFD, balancing supplemental against ambient light to meet an instantaneous threshold, while binary control switches lights on at full power. Each strategy is combined with the Lighting & Shade System Implementation (LASSI), developed at Cornell University (Albright et al., 2000). The LASSI algorithm strives to meet a target daily light integral, making lighting decisions based on expected solar DLI, the potential for supplemental lighting, the season and the time of day. The algorithm takes effect by delaying supplemental lighting each day for a number of hours determined by the season and the insolation occurring to the current time. Binary control is expected to accurately provide a target DLI, with some overshoot on cloudy days that become sunny. Modulation control is expected to precisely meet a minimum threshold DLI while minimizing overshoot of supplemental lighting. Networked microcontrollers manage LumiGrow 650e LED fixtures, and the project lays the groundwork for incorporation of additional software into dynamic greenhouse lighting systems.

Marketing and Economics (Poster)

Consumers Willingness to Pay for the “Local” Attribute of a Familiar Vegetable, Broccoli

(Poster Board #361)
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Broccoli is a major fresh vegetable crops with supply concentrated in California. There is a benefit to diversifying the sources of supply to meet a stated increase in demand for local produce, as well as improving resource use efficiency and shelf life. The “Developing an Eastern Broccoli Industry” project is underway to support the production and marketing of East Coast grown broccoli as an alternative to West Coast supplies. Plant breeders have recently released several new varieties adapted to eastern growing conditions. We selected two varieties adapted to, and grown in New York State and benchmarked them with the California variety. An auction experiment measured the consumer perception of the different varieties and the price premium they are willing to pay for local broccoli. This study also measured the effect of information about product origin on consumer quality perception and willingness-to-pay (WTP). We conducted a series of broccoli auction experiments in Ithaca and Geneva, NY, in Sept. 2017. Over 150 subjects revealed their willingness to pay for one pound of broccoli crowns of the three varieties based on their appearance and taste. We used a reduced-form econometric model to estimate the effect of the information treatment on consumers’ product perception and willingness to pay. We found that the appearance of eastern-adapted varieties was not as well-received as the California variety, but the taste was equally accepted. Consumers who were given product-origin information rated the appearance of the eastern varieties higher than those who were not given the information, showing that consumers became more forgiving after knowing the products are “local.” Consumer willingness-to-pay for the local varieties was not significant different from the California variety despite the lower ratings on appearance. Overall, the two eastern-adapted varieties showed a potential to compete with the California variety at a similar price level. Further improvement on the product appearance is likely to create a competitive advantage that could lead to a price premium.

Promoting Native Grass Benefits for Lepidoptera through Point of Sale Displays at Garden Centers

(Poster Board #362)
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Native grasses provide numerous benefits to the environment, including food and shelter for numerous species of Lepidoptera (butterfly and moth) larvae. However, this is not typically known to many horticulturists or consumers. Many Lepidoptera are incidental pollinators, hunting for nectar and transferring pollen in the process. The public values pollinators, but their valuation of pollinators depends upon their awareness and knowledge on pollinator issues and the wording of advertising materials. Consumer education can be an important tool to influence consumer preference and buying decisions. One way to influence and educate consumers is through point of sale marketing. To understand if consumer awareness of native grass benefits affected purchases, a point of sale (POS) marketing study was conducted over the course of two years at five garden centers in Minnesota. The POS materials included a poster and plant tags that listed four benefits of native grasses, including the benefits grasses provided to Lepidoptera. The POS displays were used at the garden centers for two years. We developed a one-page consumer survey to understand the influence of the POS display. The questions assessed whether a consumer saw the display, reaction to the display, their current and past purchases, awareness, attitude and knowledge of native grasses and general demographic questions. The survey was given to customers at each garden center during the gardening seasons of 2016 and 2017. A total of 341 surveys were collected over two years of which 336 were suitable for the analysis. We found consumers were less aware of the benefits that native grasses provide to butterflies and moths in comparison to three other benefits. The results were inconclusive regarding whether consumer knowledge level increased after seeing the POS display. We found that consumers that saw the POS display were more likely to purchase a native grass. The level of consumer knowledge on the benefits of native grasses was not found to influence native grass purchases. Because consumer knowledge did not influence consumer decisions to purchase a grass, we cannot confirm that an increase in awareness of benefits caused consumers to buy more grasses. Further research is needed to clarify whether consumers internalize information from POS displays, causing them to make informed decisions or whether POS displays simply draw the attention of consumers, making purchases more likely.

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Landscape Importance Components Related to Consumer Active Interest and Passive Disinterest in Water Conservation

(Poster Board #363)

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Specified Source(s) of Funding: USDA SCRI Clean Water3 — Reduce, Remediate, Recycle Grant Number 2014-51181-22372;
Economic Feasibility of Cover Crops for Organic Strawberry Production

(Poster Board #364)

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Cover crops can be used in an organic farming system to enhance soil quality and reduce weed pressure, potentially leading to higher yields and revenue that may offset their cost. Partial budgets were developed for three different cover crop treatments in an organic strawberry cropping system study. The treatments were sunn hemp (Crotalaria juncea L.), hairy indigo (Indigofera hirsuta L.), and a mix of these two with slender leaf rattlebox (C. ochroleuca G. Don) and American jointvetch (Aeschynomene americana L.). The study aimed to determine how the treatments affected profits relative to a no-cover-crop, weedy control system in the context of a Florida winter organic strawberry production season. A trial was conducted at the Plant Science Research and Education Unit in Citra, FL, to obtain yield and cost data. Cover crops were established in July 2016 and terminated that September. Four strawberry cultivars were transplanted into plastic-mulched, raised beds in October and harvested from November 2016 through April 2017. Horticultural researcher interviews, previously developed budgets, and Agricultural Marketing Service data were integrated with the experimental data to produce partial budgets for each treatment. Yield and cost data were averaged over the four strawberry cultivars and four replications. The sunn hemp and mix treatments both increased profits relative to the no-cover-crop control while the hairy indigo treatment decreased yield and thus decreased profits relative to the control. A sensitivity analysis was performed to determine hypothetical profit outcomes under differing yield and price scenarios. In all scenarios, hairy indigo reduced profits relative to the control while sunn hemp and the mix increased profits. Compared to the control, the additional profit of sunn hemp was greatest in low-yield scenarios while that of the mix’s was greatest in high-yield scenarios. Impacts on profit relative to the control across all scenarios ranged from ($5347) per acre for hairy indigo to $6287 per acre for the mix.

A breakeven analysis showed that the seed cost of sunn hemp would need to increase 9.31 times for it to have the same profit as the control. The seed cost of the mix would need to increase 16.67 times to break even with the control. Hairy indigo does not break even at any seed cost. Further research into less visible effects such as accrued soil quality benefits and reduced weed management costs is warranted to fully capture the economic benefit of various cover crops.

Economic Analysis of Anaerobic Soil Disinfestation Treatments for Tomato Production in Southwest and North Florida

(Poster Board #365)

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The main approach of anaerobic soil disinfestation (ASD) in Florida, a method for pre-plant soil treatment, consists of combining the application of the molasses (C source) with the application of composted poultry litter (CPL) as an organic amendment. However, CPL is not always available locally and is rich in phosphorous. Conventional growers are reluctant to use CPL to avoid any potential food safety issue. In this study, alternative organic amendments, such as composted yard waste (CYW) which poses no food safety issue and is inexpensive and available locally, was used as a substitute for CPL. The main purpose was to evaluate the economic profitability of treatments using alternative organic amendments. Two open-field tomato production trials were conducted at two research stations during the fall 2016 season in Immokalee and Citra, FL. Different application rates of alternative organic amendments (e.g., CYW) were compared to chemical soil fumigation (CSF) as a control. Economic profitability analysis of all eight soil treatment methods was conducted. The results showed that ASD treatment with CPL 11 Mg·ha$^{-1}$ and molasses 7 m$^3$ ha$^{-1}$ achieved the highest gross return among all treatments tested. Compared with CSF, most of the relative net returns of ASD treatments with CYW were negative. ASD treatments with CYW had lower land preparation cost than ASD with CPL, but the marketable tomato yields were lower. The relative net return of all ASD treatments with
Ornamental Plant Breeding (Poster)

A New Landscaping Garden Chrysanthemum Cultivar ‘Cushion Ball’ with Bicolor Petals, Spreading Type and Decorative Flower

(Poster Board #068)

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The garden chrysanthemum is one of the most beloved flowers in Korea. It has become increasingly being sold as pot and landscaping plants in Korea. The objective of the breeding of garden mum is to make a spreading type that can be planted on landscape area with a short plant height. ‘Cushion Ball’ is the newest garden chrysanthemum (Dendranthema grandiflorum) releases from the Flower Research Institute in Chungcheongnam-do ARES. ‘Cushion Ball’ is the result of a cross pollination between ‘09-04-73’ and ‘09-78-10’. The characteristics were investigated from 2014–16 for the evaluation and selection of this variety in natural culture condition. It is a vigorous and uniform plant that usually begins blooming in the early of October. It has decorative type flowers, bicolor with white and yellow color petals and plant shape of spreading type. The diameter of flower is 6.3 cm, the plant height is 15.5 cm, and the number of flowers is 685. These were checked local adaptability about the characteristics of growth and flowering at Yesan-gun and Suwon city.

Effects of a Floral Cut on the Retention of Eriophyid Mites on Rose Cuttings

(Poster Board #069)

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Rose cuttings from the field are treated with floral cuts to reduce the number of eriophyid mites that drop off in transit to the laboratory. The theory is that the change in osmotic pressure within the cane can trigger a mite to abandon its host. To streamline the collection process and reduce sampling time, an experiment was developed to determine the necessity of floral cuts for the retention of eriophyid mites. Four groups of plants (healthy Knock Outs, RRV infected Knock Outs, healthy multiflora, and RRV infected multiflora) were evaluated at different time intervals (0.5, 2, 4, 8, 24, 48, 72, 96 hours postharvest) to assess the number of mites per gram of tissue that were present. Cut type and rose species were not found to have a significant effect on the number of mites per gram of tissue found. Floral cuts are not needed for accurate recovery of eriophyid mites. RRV infected rose cuttings were found to have 42 times per gram as many mites per gram as healthy rose cuttings.

**Specified Source(s) of Funding:** USDA-SCRI grant “Combating Rose Rosette Disease: Short Term and Long Term Approaches” (2014-51181-22644/SCRI)

**Improved Gerbera Transcriptome Assembly Using a Combination of Four Assemblers** *(Poster Board #071)*

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Gerbera daisy is popular for its attractive flowers available in a wide array of colors. It is also used as a model plant to study flower development and secondary metabolites. Genomic and transcriptomic information and resources are very limited in gerbera, due to a number of factors including a large genome size (5.5 Gb) and a high level of heterozygosity. In this study, we sequenced and assembled the leaf transcriptomes of two gerbera breeding lines with a contrasting phenotype in flower color, flower form, peduncle length, and powdery mildew resistance. We used four different de novo transcriptome assembly pipelines: SOAP, Trinity, Velvet, and TransAbyss and produced a composite assembly of the gerbera daisy leaf transcriptome consisting of 145,348 contigs with a N50 value of 1124 nucleotides and a mean contig length of 761 nucleotides. Our experience showed that the use of multiple assemblers significantly improved the quality of the gerbera daisy leaf transcriptome compared to the assembly produced with Trinity alone. When Trinity was used alone, the assembly consisted of 528,630 contigs with a N50 value of 708 nucleotides. Gerbera daisy leaf transcripts showed highest similarities with *Helianthus annus* and *Cynara cardunculus* var. *scolus* (both belonging to Asteraceae family), with 13,888 and 13,406 gerbera transcripts similar to the genes of the latter two species, respectively. The high quality gerbera daisy leaf transcriptome assembly should facilitate downstream analyses of gerbera transcriptome including transcript quantification, identification of differentially expressed genes, and identification of candidate genes in gerbera resistance to powdery mildew.
Identification and Characterization of Rust Resistant Lines from Dwarf Mutants of Perennial Ryegrass (Poster Board #072)

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Perennial ryegrass (Lolium perenne, L.) is an important cool-season turfgrass species which is widely cultivated around the world. Perennial ryegrass is very fast to establish, which makes it very favorable for ornamental use. Crown rust (Puccinia coronata Corda f. sp. lolii) is one of the most devastating fungal diseases of perennial ryegrass, causing significant economic losses worldwide. Rust infections can be controlled by fungicide chemicals, but the approach is pollutive and expensive. However, breeding rust resistance cultivars of perennial ryegrass may provide a better solution. We have isolated 16 dwarf mutants from an ethyl methanesulfonate (EMS)- and gamma-treated population of “Fiesta 4” cultivar of perennial ryegrass. Under a field condition, we have observed that the wildtype “Fiesta 4” plants were severely infected by rust with an average score of 4.9 (a score of “5” indicates all leaves were infected by rust while “0” is indicative of no infection). Meanwhile, under the same condition, some mutant plant lines scored 0 on average, and the others had an average score of 1-3. It appears that the rust resistance is related to the degrees of dwarfness of the mutant lines. We are currently further evaluating a small number of the rust resistant mutant lines under growth chamber conditions. The mutants identified from this study may provide valuable resources for understanding of the mechanism of rust resistance observed in our dwarf mutants and also for breeding of novel rust resistant perennial ryegrass cultivars.

Specified Source(s) of Funding: UConn College of Agriculture

Heritability of Flower Size and Heat Stress in Diploid Roses (Poster Board #074)

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Heat stress on roses (Rosa ×hybrida) negatively affects rose performance and reduces the market value of the crop. The effect of heat on flower size was assessed with a heat shock treatment (44 °C for 1 hour) and in the field during the cool (~20 °C) and warm (~30 °C) seasons of the year for 10 and 9

An asterisk (*) following a name indicates the presenting author.
interrelated diploid rose populations respectively. The elevated temperature caused a decrease in flower size under both conditions for flower diameter (~16-18%), petal number (~23 to 17%), and flower weight (~17 to 32%). Flower size showed low to moderate (flower diameter, 0.24–0.38; petal number, 0.12–0.26; flower weight, 0.34–0.53) narrow and moderate (flower diameter, 0.62–0.70; petal number, 0.74–0.91; flower weight, 0.76–0.88) broad sense heritability inferring a major non additive genetic component for flower size. Differences in heat tolerance would indicate that roses respond differentially to the environment (heat stress). Thus in a genetic variance analysis, a high GxE variance would indicate genetic differences in heat stress. Among the three size parameters, flower diameter showed the largest GxE genetic variance. The populations were genotyped using genotyping by sequencing and the SNPs were used to create a consensus map with JoinMap 5. Using the consensus map in FlexQTL, a pedigree based QTL analysis software, for flower petal number, flower diameter, and flower dry weight was done.

**Specified Source(s) of Funding:** “RosBREED: Combining Disease Resistance with Horticultural Quality in New Rosaceous Cultivars” (2014-51181-22378/SCRI) and “Combating Rose Rosette Disease: Short Term and Long Term Approaches” (2014-51181-22644/SCRI).

**The Search for Resistance to Rose Rosette Disease (Poster Board #075)**

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Rose rosette disease is caused by the Rose Rosette Virus (Emaravirus) and transmitted by the eriophyid mite Phyllocopets fructiphilus. Since 2015, the Combating Rose Rosette Disease SCRI project has been evaluating a wide range of rose germplasm for its resistance to RRD in replicated plots in Tennessee, Delaware, Oklahoma, and Texas. In addition, observational data was collected from a number of gardens. Thus far, about 900 rose accessions have been observed. Of these 900 accessions, 850 have developed typical symptoms of RRD although most have not been tested to verify that the virus is present in the plant. The first replicated trials were planted in Tennessee and Delaware and contained 227 unique rose accessions with 68% planted at both sites. The disease pressure in these sites was augmented by attaching symptomatic shoots with mites from infected plants to the test plants. After two years in the field, there are still 34 rose accessions that have not yet shown symptoms nor have been detected with the virus. This includes 12 garden roses, 7 rugosa hybrids, 8 Rosa species accessions, and 8 selections from the TAMU breeding program. These will be tested for one more season to confirm their resistance to the disease.

**Specified Source(s) of Funding:** NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

**Confirmation of Hibiscus Syriacus Allotetraploid Genome and Disomic Segregation Patterns Using rDNA Fluorescent In Situ Hybridization. (Poster Board #076)**

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**Hibiscus syriacus** is a woody ornamental shrub in the Malvaceae family and is commonly found throughout much of the United States due to its broad adaptability and variability of ornamental characteristics. Although *H. syriacus* is a very popular ornamental plant, little is known about its pattern of inheritance of ornamental traits such as flower color and petaloid stamens. *Hibiscus syriacus* has been identified as tetraploid based on its chromosome number (2n = 4x = 80); however, relatively little additional cytology or genetics information is available. In this study, a hexaploid (6x = 120) cultivar ‘Pink Giant’ was used to cross with tetraploid (4x) cultivars, and to create putative pentaploids (5x). Fluorescent *in situ* hybridization (FISH) was used to determine 45S and 5S rDNA loci numbers of 4x, 6x, and putative pentaploids. For the 4x and 6x cultivars, 4 and 6 signals of 45S rDNA58 were observed; however, only 2 and 3 signals of 5S rDNA were detected. Furthermore, the signal numbers of these putative pentaploids varied among siblings. The segregation patterns of rDNA signals in *H. syriacus* appeared to be random among the putative pentaploids and signals for each rDNA site ranged between the values of the two parents. Both the 5S rDNA loci numbers and the random segregation loci of putative pentaploids indicated that the *H. syriacus* genome presented with disomic segregation. In addition, the variation in rDNA loci number indicated that the putative pentaploids were actually aneuploids. This information is valuable for targeted *H. syriacus* breeding in that it will allow prediction of segregation patterns of ornamental traits.

**Specified Source(s) of Funding:** Oregon Department of Agriculture

An asterisk (*) following a name indicates the presenting author.

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Evaluation of Garden Rose Species, Cultivars, and Breeding Populations for Disease Resistance and Landscape Performance in Texas

(Poster Board #077)

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In 2015 and 2016, plants of almost 300 garden rose entries were field planted in Overton, Texas for evaluation of disease development and landscape characteristics. The entries included species and modern roses including hybrid tea, hybrid rugosa, and traditional and modern shrub type roses. Plants were planted in a randomized complete block design and evaluated monthly during the 2017 growing season for disease incidence of black spot (Diplocarpon rosae) and landscape performance. During the growing season at Overton, overall black spot incidence varied from 4.1 in June and July to 5.1 in November using a rating scale of 0–9 with 0 representing a total lack of disease and 9 denoting all foliage infected with heavy defoliation and reduced plant vigor. Many species roses such as Rosa bracteata and hybrids such as John Davis and Oso Happy Candy Oh exhibited the lowest black spot ratings. Highest ratings were given to primarily commercial cultivars such as Intrigue and Linda Campbell. Also, in 2017 a breeding population was rated to evaluate disease incidence. Rust was seen for the first time in the Overton plantings in this population and was only present in the R. setigera crosses. Forty percent of the seedlings of R. setigera × ‘Bayse’s Thornless’, 20% of the seedlings of R. setigera (or R. s. serena) × ‘Pink Gnome’, and a seedling of R. setigera × X566-81 were rust free. All crosses involving ‘Driveway Red’ with R. setigera or R. s. serena were rust free. This information will be valuable for genetic studies and for determining entries useful for future breeding.

Characterizing and Identifying Black Spot Resistance Genes in Polyploid Roses

(Poster Board #078)

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The ornamental quality of outdoor grown roses (Rosa hybrida) is under constant threat from foliar diseases, such as black spot caused by Diplocarpon rosae. Fungicides are primarily used to manage black spot; however, there is a high consumer demand for disease resistant roses which eliminate the need for chemical inputs. Phenotyping with 12 D. rosae races was conducted to better characterize resistance in four popular polyploid rose cultivars (Brite Eyes™, High Voltage™, Lemon Fizz™, and Morden Blush). Subsequently, two populations (‘Morden Blush’ × Brite Eyes™ and High Voltage™ × Lemon Fizz™) were developed to study resistance segregation and map the genes mediating black spot resistance using the rose Axiom array. ‘Morden Blush’ was susceptible to all races while the remaining three cultivars displayed differing disease responses. A 1:1 segregation ratio was observed for the two populations where each individual was either resistant or susceptible to all races tested to date, suggesting resistance is conferred by a single resistance gene in Brite Eyes™ and Lemon Fizz™. High Voltage™ is expected to have a different resistance gene than Brite Eyes™ and Lemon Fizz™ based on observed disease responses. Linkage mapping in the ‘Morden Blush’ × Brite Eyes™ population identified a single resistance gene that mapped to a chromosome 5 homeolog (Rdr4). To date, three black spot resistance genes, Rdr1, Rdr2, and Rdr3, have been identified. Rdr1 and Rdr2 both map to chromosome 1 indicating they are not allelic to Rdr4 and the location of Rdr3 is currently unknown. D. rosae races 3 and 9 are virulent on Rdr3 but avirulent on Rdr4. As such, we cannot confirm if Rdr4 is a unique gene or an allele of Rdr3. Future work will focus on developing tools for marker assisted breeding and pyramiding the identified resistance genes into new cultivars.

Specified Source(s) of Funding: USDA-ARS-NIFA project ‘RosBREED: Combining Disease Resistance and Horticultural Quality in New Rosaceous Cultivars’ (2014-51181-22378)

Combatting Rose Rosette Disease with the Use of Web-Based Outreach Tools to Engage Volunteers for Research

(Poster Board #079)

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In 2014, the project entitled “Combatting Rose Rosette Disease:
Short-term and Long-term Approaches”, was funded by a NIFA Specialty Crop Research Initiative grant to address the growing impact of this disease on the rose industry. Rose breeders are searching for resistant germplasm that can be used to develop roses with resistance to Rose Rosette Disease (RRD). To date, no cultivated rose has been confirmed resistant to the virus that causes this disease. An effort to reach out and seek public involvement to help accelerate the research was executed. A website (http://roserosette.org) was developed to serve as a clearinghouse of RRD information for the general public, but also to engage and recruit the public to assist in monitoring for RRD. This reporting tool that was launched in the 4th quarter of 2017, aims to encourage the report of suspected RRD and the rose cultivars where these symptoms were observed. To date (15 Mar. 2018), this reporting system has registered 197 reports submitted. 13 have been verified via visual (photograph), 143 are credible or plausible reports and 30 had been confirmed by PCR. This website and the reporting tool is being actively marketed at current time. We anticipate a continued increase in usage and recovery of valuable information that would inform and help to accelerate our efforts to discover current cultivars with resistance to RRD.

Specified Source(s) of Funding: NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

Poster Presentations

Ethanol Treatment Induces Compact Growth in Euphorbia pulcherrima (Poster Board #325)
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One of the most important characteristics of ornamental potted plants is their proper compact growth habit. The most common way to achieve compactness during plant production is usage of chemical growth retardants. However, some of these chemicals have a hazardous character and have been prohibited in a range of European countries due to their toxicity to humans and negative impact on environment. In our studies we investigated the influence of ethanol treatment on a growth habit of a popular ornamental potted plant Euphorbia pulcherrima cv. Premium Ice Christal. During vegetative growth the plants were watered with ethanol solution in concentrations: 0, 0.5, 1, 2, 4, or 8%. All concentrations of ethanol, except 0.5%, resulted in more compact growth than control plants, however, the concentrations of 4% or 8% caused chlorotic and necrotic spots, or in some cases even death of the plant. Fresh and dry weight, and plant diameter decreased when concentration of ethanol increased. No delay in coloration of bracts was observed. Ethanol treatment used in appropriate concentrations appears to be an excellent alternative to chemical growth retardants for induction of compact growth. Ethanol is inexpensive, biodegradable material, non-toxic in proper concentrations, which can easily be integrated into a commercial production.

Influence of Paclobutrazol on Growth, Composition and Number of Different Shoots in High Density Pecan Orchard (Poster Board #326)
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Close spacing is the fastest way to generate a lot of pecans in early years. With the application of much better precocious cultivars and improved horticultural technologies, high density pecan production could be achieved. Like some other fruit trees, most of the fruits bear only on the shoots with terminal growth less than 30 cm. However, young pecan trees always have vigorous vegetative growth with the terminal growth greater than 50 cm. It’s difficult to generate pecans on young trees. This experiment was carried out to: 1) evaluate the effects of paclobutrazol on inhibiting pecan vegetative growth and increasing the number of bearing branches; and 2) investigate composition of different kinds of branches. The study was conducted from 2012 through 2014 in a 6-year-old pecan orchard in Nanjing, Jiangsu, China. ‘Mahan’ trees were spaced 5 × 7.5 m apart. Trees appeared to be crowding as limbs began to intermesh within rows. Most new branches grew more than 30 cm but did not form flower buds. Paclobutrazol (15% a.i.) was applied to trees soil drench (rates of 0, 30, 90, and 150 mg/cm² trunk cross-sectional area). The four treatments initially were applied in a randomized complete-block design to three replications. Terminal shoot growth was measured in Apr. 2013 and 2014, and 10 terminal shoots were selected on each of four sides of the tree at the height of maximum limbspread. Compared with the control, the application of PBZ treatments significantly increased the number of branches (less than 30 cm) by 76.4%, 141.0%, 54.0% respectively, and decreased branches (greater than 30 cm) by 48.3%, 64.2%, 60.3%, respectively. The cumulative growth of current-season shoots was significantly inhibited in comparison with the control. The chlorophyll content of leaves was significantly increased in response to paclobutrazol application.

Molecular Characterization of the Role of Weep in Directing Branch Orientation in Peach Trees (Poster Board #328)
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Control of shoot architecture is a fundamental aspect of plant growth and development. The dissection of molecular mechanisms controlling architecture is important for understanding the basic biological question of ‘how plants grow’ while also...
having potential agro-economic impacts. Manipulation of shoot architecture allows plants to acquire sufficient levels and quality of light. Variation in the architecture of fruit trees can improve fruit quality and size as well as potentially reducing the cost of training, production, and orchard maintenance. Recently, a mutation in the uncharacterized and highly conserved WEEP gene was identified as the cause of a downward growing (weeping) growth habit in peach, implicating WEEP in the control of lateral shoot growth in trees. Here, we begin to elucidate the molecular mechanism of WEEP and its effect on branch growth. Weep branches were subjected to a 4-point bending test, which demonstrated similar structural properties as standard peach branches, rejecting the hypothesis that the downward-growing weeping growth habit results from weak or ‘floppy’ branches. Histological and wood chemistry analyses were conducted to determine how changes in the cell wall could lead to alteration of branch growth habit. However, no obvious differences between weep and standard peach in the quantity or distribution of cell wall polymers were observed. Fiber cells of weep were found to be slightly shorter than those of standard peach, suggesting a role for WEEP in cell elongation. To investigate biochemical roles of WEEP, we have developed a specific antibody to this protein and are currently investigating its subcellular localization, expression pattern, and are using co-immunoprecipitation to discover interacting protein partners. This characterization will aid in understanding molecular function and pathways of WEEP and how this protein contributes to the control of lateral shoot architecture in trees.

Specified Source(s) of Funding: USDA NIFA Award #2018-67013-27457

The Impacts of Altering Source–Sink Dynamics on Non-climacteric Pepper Ripening On- and Off-plant (Poster Board #329)

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Bell pepper, Capsicum annuum L., is one of several, highly-valued greenhouse crops. However, because they are non-climacteric, if bell peppers are harvested green, they stay green. For green peppers to turn red, the ripening process requires an extra 20 to 30 days on the plant. The aim of this study was to investigate source-sink dynamics during pepper ripening on- and off-plant. To examine the impacts on on-plant ripening, source-sink dynamics were altered by various levels of leaf removal and complete removal of the phloem when fruit were at either green or breaker. Physiological parameters such as fresh weight, firmness, colour, total carotenoids and chlorophylls were then measured at 0, 5, 10, 15, and 20 days after treatment (DAT). Compared with breaker-treated fruit, green fruit from plants where leaves and phloem had been removed showed a delay in the on-plant ripening process until 15 DAT. Furthermore, the greater the leaf removal rate, when fruit were green, the greater the delay to colour development and carotenoid content. Interestingly, phloem removal from plants when fruit were green not only significantly delayed the ripening process but also resulted in significantly higher fresh weight between 5 DAT and 15 DAT when compared to control fruit. Together, these results suggest important roles for sugar availability in on-plant pepper ripening. With 80% leaf removal having the greatest impact, this treatment was then selected to examine the effects on the behaviour of fruit during storage at 0, 6, 12, and 20 days after harvest. However, there was no effect of the preharvest leaf removal on any physiological parameter related to ripening during postharvest storage. Therefore, although source-sink dynamics appear to be important for pepper ripening on the plant, there may be other triggers for induction off the plant that require investigation.

Micropropagation of Epidendrum nocturnum, an Endangered Native Orchid Using Organic Media (Poster Board #330)

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Overharvesting and deforestation has led to the critical endangerment of many native South Florida orchid species. Conservation efforts of these rare orchids has, in the past, proven difficult, as the propagation of orchids in nature is uncommon. Due to their tiny, dust-like seeds, which lack an endosperm, orchids require assistance from species-specific mycorrhizal fungi that form a symbiotic relationship with the orchids, in which the fungi provides nutrients for germination and embryo development. Because of this complex specialized relationship, germination rates in nature are exceedingly low. Using in-vitro micropropagation methods, in which artificial growth mediums provide the necessary nutrients, thus, eliminating the need for the fungi symbiont, germination rates can reach nearly 100%. Epidendrum nocturnum is an imperiled (IRC) native south Florida orchid species and the focus of this study. E. nocturnum is epiphytic with fragrant yellowish and white flowers ranging from 3–5 inches. Traditionally, the orchid grows on a variety of trees throughout the swamps and hammocks of south Florida. The aim of this study was to use biotechnological conservation methods to develop a protocol for the micropropagation of E. nocturnum using organic amendments in the growth medium.

Specified Source(s) of Funding: USDA-NIFA Hispanic Serving Institutions Higher Education Grants Program (2016-03476-2009)
**Investigating Silicon As a Beneficial Nutrient for Leafy Green Crops (Poster Board #195)**

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Silicon (Si) accumulator species such as rice, wheat and cucurbits can absorb and accumulate soluble silicate under normal growing conditions and gain beneficial effects from the Si deposit under the cuticle. However, Si non-accumulator species such as leafy green vegetables have not been investigated very much. Recent studies have found that some Silicon non-accumulator species can start uptake Si and obtain benefits when under biotic or abiotic stresses. We investigated different levels of silicon amendments to the nutrient solutions of several hydroponically grown leafy green crops (lettuce, basil and bok choy, representing the common leafy green vegetable families Asteraceae, Lamiaceae and Brassicaceae), and observed the Si uptake and plant growth characteristics under heat & cold stress or physical damage. Basil with Si amendment showed significantly increased cold tolerance. Si amended lettuce and bok choy showed moderate increase in heat tolerance. The Si levels in basil, lettuce and bok choy plant tissue were increased after cut and grow back treatment. Our results indicate Si is an overall beneficial nutrient to the non-accumulator species.

**Effect of Turfgrass Species on Water Extractable Inorganic Nitrogen and Phosphorus (Poster Board #196)**

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Eutrophication of urban surface waters is a significant problem associated with excess nutrient pollution. Historically, regulatory agencies have attributed urban eutrophication to fertilizer use in lawns and golf courses. Scientific evidence suggests nutrient pollution from turfgrasses can be minimal if fertilizer is applied according to best management practices. Specifically, numerous reports have shown that applied fertilizer is quickly taken up by turfgrass roots and made unavailable to environmental losses. Whether nitrogen (N) and phosphorus (P) content of turfgrass plants influences the nutrient content of runoff is undocumented. The objective of this study was to directly assess the leachability of N and P from turfgrass above-ground tissues in order to simulate the effects of runoff moving through a turfgrass field. Bermudagrass (Cynodon dactylon) and perennial ryegrass (Lolium perenne) were established in 5 cm diameter pots containing a calcined clay (Turface MVP) rootzone. Treatments consisted of four N (urea) rates (0, 100, 200, 300 kg·ha⁻¹ N) and three P (triple superphosphate) rates (0, 10, 100 kg·ha⁻¹ P). Other plant essential nutrients were applied to prevent deficiencies using a commercial fertilizer. After six weeks of treatments, above-ground plant tissue was harvested and clipped to a uniform size before being subjected to a water extraction procedure. The extractant was filtered and analyzed for nitrate-N, ammonium-N, and orthophosphate-P concentration. Plant tissue N and P concentration were measured using reserved above-ground tissue. Relationships between application rates, plant tissue nutrient concentration, and extractable nutrient concentration varied between turfgrass species. In bermudagrass, N tissue content increased with increasing N rate while extractable dissolved inorganic N decreased. A similar pattern was seen for P rates in bermudagrass. In ryegrass, P tissue content decreased with increasing P rate suggesting faster growth under higher P rates led to nutrient dilution in plant tissues. These findings suggest healthy turfgrass tissue (lacking in nutrient deficiency) would not likely be a direct source of inorganic nutrients in an urban watershed.

**Mineral Content of Cilantro in the Condition of Combined Drought and Salt Stress (Poster Board #197)**

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Salinity and drought are the main and common abiotic stresses that reduce crop growth and the productivity in addition to plant nutrient uptake is very sensitive to environmental stress factors. In this study we focused on the cilantro (Coriandrum sativum L.) mineral content and their transformations under abiotic stress conditions. For this aim we conduct a greenhouse experiment with different level of salinity and drought treatments. Four different salt doses (A0: 0 mM NaCl, A1: 50 mM NaCl, A2: 100 mM NaCl, and A3: 150 mM NaCl) and three different irrigation levels (I0: 100%, I1: 75% and I2: 50% of the water required to reach the field capacity) were applied and individual and combined effects of two stresses were evaluated. Both drought and salinity altered the mineral-nutrient relations by decreasing N, P, K, Ca, Mg, Cu, Mn, Fe and Z of the coriander plants in general but Na, and B content of the plants were increased. The decrease in the content of N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn were 27%, 29%, 15%, 17%, 13%, 7%, 22%, 20%, and 15% respectively in severe drought stress treatment (I2) and were 56%, 57%, 48%, 56%, 33%, 46%, 35%, 32%, and 27% respectively in severe salinity stress treatment (A3).
in severe salt stress (A3) compared to control. The combined stress treatments (I2A3) caused more reduction in the content of N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn (70%, 67%, 61%, 65%, 56%, 65%, 58%, 58% and 50% respectively). On the other hand increase of Na and B were 45% and 24% in I2, 51% and 35% in A3 and 118% and 78% in I2A3. The results of this study state that the effect of salt stress on cilantro was more destructive compared to drought stress. Besides, coexistence of the drought and salinity stress was deteriorated and the results demonstrate their roughly additive effects on the plant mineral content.

Using Sprinkler Irrigation and Fertigation to Save Water and Nutrients for Potato Production in Florida (Poster Board #198)
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Sustainable management of water and fertilizers is imperative for Florida’s vegetable production. To save irrigation water and increase nutrient use efficiency for commercial potato production, we conducted a fertigation trial to explore the feasibility of adopting fertigation in Florida potato. The objectives were to: 1) evaluate water savings for commercial potato production using a sprinkler irrigation system and 2) determine the most efficient application method for fertigation in potato production. The effect of the sprinkler irrigation and hybrid irrigation systems on potato growth and development, whole plant physiol- ogy, and tuber yield and quality was assessed. Subsequently, two fertigation trials were completed in Hastings and Parrish, FL. The trial in Parrish in Manatee County had two treatments including fertigation and dry granular fertilization. The results showed that the tuber yield of the chipping cultivar ‘Atlantic’ (season 2015–16) had a 19% increase and the table cultivar ‘Red LaSoda’ (season 2016–17) had a 24% increase compared with the fertigation treatment than with the other treatment. Also, another trial was conducted at UF/IFAS Hastings Agricultural Extension Center (HAEC) research farm to explore the best approach to fertigate potato plants. Eight fertigation treatments and four dry granular fertilization treatments were completed with different fertigation times and nitrogen rates. The results showed that five fertigation events each with total 10 lbs N/acre was the best combination for Florida potato. The fertigation treatments had greater tuber yield than the dry granular fertilization treatments. Fertigation may become an effective BMP tool for potato production in Florida.

Specified Source(s) of Funding: SWFWMD

Determining the Effect of Aluminum Sulfate Application on Red Hydrangea Sepals (Poster Board #199)
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Hydrangeas (Hydrangea macrophylla) contain an anthocyanin pigment within the sepal that naturally produces a pink or red color. In the presence of aluminum (Al) the pigment will bind with the Al producing a blue or purple color. While most hydrangeas are marketed as a pink or blue there are some red cultivars. Red cultivars are managed similar to pink varieties in order to express their true red coloring. The purpose of this study was to determine if applications aluminum sulfate [Al₂(SO₄)₃] would change the color of the true red sepal. We treated ‘Hot Red’ hydrangeas with 0, 1.2, 1.8, 2.4, and 3.0 g/L of Al₂(SO₄)₃ applied during weekly irrigations. We measured the Al levels in the sepal, leaf tissue, and substrate leachate by ICP analysis at full bloom. Sepal colors were evaluated by visual analysis and measured using a handheld colorimeter. There was a positive correlation between the concentration of Al₂(SO₄)₃ applied and the level of Al in the sepal, leaf tissue, and substrate leachate. Regression models illustrated that each tissue continued to accumulate higher concentrations of Al as the Al₂(SO₄)₃ concentration increased. There was a noticeable change in sepal color with increasing concentrations of Al₂(SO₄)₃. Color data indicated that higher Al₂(SO₄)₃ concentrations resulted in darker sepalos with more blue and less red coloration. Based on the findings, growers producing ‘Hot Red’ hydrangeas have the ability to manipulate the sepal coloration by applying Al₂(SO₄)₃.

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Spinach Response to Zinc Fertilizers in the Desert (Poster Board #201)
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Vegetable crops produced in the Arizona desert have always

An asterisk (*) following a name indicates the presenting author.
shown large yield and quality responses to nitrogen (N) and phosphorus (P) fertilization. Soil test based fertilizer recommendation of N and P have been developed by the Universities and N and P fertilizers are commonly used to optimize production. Because our irrigation water has K, and our soils have abundant K-bearing minerals, response to K fertilizers are very infrequent and K fertilizers are rarely used. This desert region in Arizona has been classified as an area prone to zinc (Zn) deficiency. This is due to soil pH values greater than 7.5, and the presence of carbonate that ties up plant available Zn. However, measured crop responses to Zn had been lacking and the routine application of Zn fertilizer could not be economically justified. More recently, we have found spinach produced in this region often showed yield responses to low levels of Zn fertilization. In fact, we observed spinach yield responses in about 50% of the field studies we conducted. Interestingly, in a follow-up survey we found about 50% of the soils used for spinach production had DTPA soil-test Zn levels less than 1 ppm indicating a response to Zn was possible.

*Specified Source(s) of Funding: SCBG*

**Nitrate and Phosphate Losses from Organic versus Inorganic Soilless Root Support Substrates during Nonrecirculating Hydroponic Culture of Swiss Chard (Poster Board #202)**

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This study compares the relative rate of nitrate and phosphate losses, and crop yield from 100% coconut coir (organic) or perlite (inorganic) soilless root support substrates (SRSS) during the culture of Swiss chard (*Beta vulgaris* L.) cv. Acelga in a nonrecirculating hydroponic system (NRHS). Excess nutrient solution (15N–2.2P–12.5K plus micronutrients, supplied at 200 mg·L⁻¹ nitrogen, pH 6.5–7.2) delivered by drip emitters to the SRSS during each cropping cycle, flowed to drainage via 2-inch PVC pipes. Mean ambient day/night temperature and relative humidity during the cropping cycle were 22.9/8.5 °C and 86.5/54.0%, respectively. We grew Swiss chard seedlings from the third true-leaf stage until the second harvesting at 103 days after transfer into hydroponic culture (DAT). Weekly leachate sampling from the NRHS for determination of nitrate and phosphate concentration started when the seedlings were fully established and capable of active mineral nutrient absorption. We analyzed the samples for nitrate and phosphate using the Dionex™ ICS-5000+ Capillary High Performance Ion Chromatograph System equipped with conductivity detector. Compared with the inorganic, the organic SRSS significantly reduced leachate nitrate and phosphate concentration by ~78% (P < 0.0130) and ~66.5% (P < 0.0001), respectively, compared with Perlite over a 103-day sampling period. The organic and inorganic SRSS reduced nitrate leaching losses by 77.8% (P = 0.0004) and 51.4% (P = 0.0113), respectively, compared with the source nutrient solution (SNS) collected from the emitter. Although the phosphate concentration of the leachate were 56.2% and 38.0% less than that of the SNS in the organic and inorganic SRSS, respectively, overall differences averaged over the cropping period were not significant (P = 0.05), due to variability between batches of samples. Crop grown in the organic SRSS had significantly greater marketable leaf yield and leaf dry weight (LDW) (P < 0.05), but there were no differences in leaf count. Crop grown in the organic SRSS had higher leaf water content (LWC) (P < 0.0047) compared with the inorganic in one of the two replicates of the experiment. Reductions in nitrate and phosphate losses by both organic and inorganic SRSS over the cropping period can amount to significant savings in fertilizer cost at the percentages observed in this study. However, the organic SRSS shows a greater capacity to minimize potential environmental pollution by nitrate or phosphate discharge from small-scale nonrecirculating hydroponic operations, without limiting the growth and leaf yield of Swiss chard.

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**Effect of Phosphorus Fertilizer Placement on Growth and Yield of Tomato in a Calcareous Soil (Poster Board #203)**

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The right placement of phosphorus (P) fertilizer can help overcome P fixation in calcareous soils. Banding application, including surface and deep banding, concentrates P fertilizer in narrow zone to provide higher nutrient concentration and less P fixation than broadcast application. The surface banding is preferred in vegetable production since it is a simple field application method. However, the movement of P to the root zone becomes a major concern when P is applied as surface banding. Thus, the objective of this experiment was to compare surface banding with deep banding based on the growth and yield of tomato (*Solanum lycopersicum*, cultivar Ridgerunner) grown on a calcareous soil. One field trial was conducted during the winter growing season of 2015 in Homestead, FL, using plasticulture system with drip irrigation. Treatments included control (without any P addition), deep banding (78 kg·ha⁻¹ of P, incorporated into 4-inch deep soils after surface banding), and surface banding (78 kg·ha⁻¹ of P, applied in two bands with 2-inch width and 6 inches away from the bed center). Data collection consisted of
An asterisk (*) following a name indicates the presenting author.

**Poster Presentations**

### Altered Chemical and Physical Properties of Aging Coir Dust Root Substrate and Their Influence on Growth of Tomato and Pepper Seedlings (Poster Board #204)

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This study was conducted to investigate influences of the aging of coir dust used as a root substrate for growing tomato and hot pepper seedlings in plug trays. The raw coir dust was placed in the greenhouse and moistened with ground water and turned over once in every two weeks. At each time of moistening and mixing, the aging coir dust was characterized for its physical and chemical properties while being used as root substrate for seedling culture. The percentage of substrate particles in 0.355 mm to 1.4 mm sizes increased as they became aged in comparison to the raw coir dust. The total porosity and air-filled porosity of aging coir dust decreased until week 12 and then increased until week 24 of aging, showing a quadratic response curve. However, container capacity of the root substrate increased until week 12 and then remained unchanged. The pH of the root substrate changed from 5.04 at week 0 to 6.0 at week 4 and remained in the range of 5.6 to 6.0. The electrical conductance (EC) changed from 9.19 dS·m⁻¹ for non-aged coir dust to 1.8 dS·m⁻¹ for aged coir dust after 4 weeks. The root substrate concentrations of major cations (K⁺, Ca²⁺, Mg²⁺) and anions (Cl⁻, PO₄³⁻, SO₄²⁻) decreased until week 4 of coir dust aging treatment. Although ammonium form of nitrogen (NH₄⁺-N) and nitrate form of nitrogen (NO₃⁻-N) decreased during the early stages of coir dust aging, NH₄⁺-N concentrations stayed in the range of 30 to 60 mg·L⁻¹ after week 4, while NO₃⁻-N started to increase after week 8. When grown for 4 weeks, the fresh weight of tomato seedlings increased linearly as the aging time for coir dust used in the root substrate increased. The relationship between the fresh weight of hot pepper seedlings and the coir dust aging period showed a quadratic response when determined for 5 weeks of culture.

### Influence of Different Nutrient Solution NH₄⁺ to NO₃⁻ Ratios on Photosystem II Photochemistry and Thermal Energy Dissipation in Hydroponically Grown Lettuce (Poster Board #205)

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The objective this experiment was to study the influence of various ammonium (NH₄⁺) to nitrate (NO₃⁻) ratios on growth, photosynthetic pigment composition, and photosynthetic apparatus associated with photosystem II (PSII) photochemistry and thermal energy dissipation in hydroponically grown lettuce (*Lactuca sativa* L.). Two lettuce cultivars (Rex RZ, Black Seeded Simpson) were grown with hydroponic nutrient solutions containing 5 different NH₄⁺: NO₃⁻ ratios (100:0, 75:25, 50:50, 25:75, 0:100, adjusted to total 12 meq·L⁻¹ N) and evaluated during the first (T1) and second (T2) week of culture. Plants grown under higher NH₄⁺: NO₃⁻ ratios exhibited significantly suppressed shoot growth with a poorly developed root system, dark-green leaves, and less water and nitrate uptake. On the other hand, plants grown under higher NO₃⁻: NH₄⁺ ratios exhibited vigorous shoot growth with well-developed root systems and high water and nitrate uptake. There were strong correlations between growth parameters and photosynthetic pigment stoichiometry as well as ratios. Total chlorophyll content increased, but the ratios of Chl a/b and carotenoid x+c/Chl a+b decreased progressively with increasing NH₄⁺: NO₃⁻ ratios, which are associated with a greater increase in Chl b. There were significant changes in PSII efficiency under different NH₄⁺: NO₃⁻ ratios for cultivar Rex RZ during the T1 period, however these changes are likely to be temporal and cultivar-dependent. In this study, the steady-state chlorophyll fluorescence (Fs) was directly correlated with total biomass and maximum efficiency of PSII photochemistry (Fv'/Fm') and inversely correlated with non-photochemical quenching (NPQ) under different NH₄⁺: NO₃⁻ ratios, but no clear correlation with quantum yield of PSII electron transport (Fps'/Fm') and photochemical quenching coefficient (qP). Values of parameters Fps' and qP were strongly influenced by Fs, leading these values to peak at 25% NO₃⁻ ratio and then decrease with increasing NO₃⁻ ratios. Leaves under high NH₄⁺: NO₃⁻ ratios exhibited increases in Fps' (actual PSII efficiency) but maintained Fno' and Fnp' unchanged. However, leaves under high NO₃⁻: NH₄⁺ ratios kept Fps' and Fnp' unchanged but significantly increased Fno' enhancing thermal dissipation of the light absorbed by PSII within the antenna bed.

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Nitrogen Level Influences Root Growth Dynamic and Shoot Components of Young ‘Arbequina’ Olives (Poster Board #206)

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Olive (Olea europaea L.) is considered one of the most important agricultural crops worldwide with an olive oil production of about 2.8 million tons in 2016. The influence of nitrogen (N) levels and sources on olive growth have been commonly researched in established orchards, but is limited in young olive plants, especially on the effects of root dynamic and physiological traits. The objective of this two-years field study was to evaluate the effects of N levels and sources on root growth dynamics, leaf-level gas exchange (photosynthesis ($P_n$), transpiration ($E$), and stomatal conductance ($g_s$)) and leaf nutrient content of young ‘Arbequina’ olives. Nitrogen treatments were, control (no N), nitrate ($NO_3^-$) form applied as calcium nitrate (CN) at 20, 40 and 60 kg·ha$^{-1}$, and ammonium ($NH_4^+$) applied as urea at 20, 40 and 60 kg·ha$^{-1}$. Root analysis derived from minirhizotron images revealed that the application of N significantly reduced root length intensity ($L_a$, mm·cm$^{-2}$) compared to control olives in both years. In addition, no significant difference was noticed between N forms for $L_a$ in 2015. In fact, leaf N% in control olives was above the N deficiency thresholds; i.e. 2.1% in 2015 and 2.57% in 2016. In both years, control-untreated seedlings had higher plant height, stem diameter and branch number than olives that received 40 or 60 kg·ha$^{-1}$ N. We attributed the high performance of control (no N) seedlings to adequate N level in the soil ($NO_3^-$ ~ 25 mg·kg$^{-1}$) from previous year application and the extra N supply from irrigation water and rainfall. However, leaf mineral concentrations were inconsistent (P, Ca$^{2+}$, Na, Zn, Fe, Cu) or not significant (Mn, S, and B). In addition, no significant difference was noticed between treatments in gas exchange ($P_n$, $g_s$, and $E$). Overall, N applied to reach the sufficiency leaf N threshold level (2%) in olive reduced $L_a$. In addition, N application may not be required if preplant soil NO$_3^-$ levels are normal (~ 25 mg·kg$^{-1}$).

Specified Source(s) of Funding: Texas Department of Agriculture, Specialty Crop Block Program

Onion Response to Stabilized Municipal Solid Waste Compost and Sulphur Amendments (Poster Board #207)

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Plant growth and bulb quality of onion (Allium cepa L.) are responsive to sulphur (S) and nitrogen (N) interaction, but compost and S interaction is understudied. This study was performed to assess the response of onion cv. Safran to stabilized municipal solid waste compost (MSWC) and sulphur (Magnesium sulphate) amendments in a greenhouse container-experiment. The treatments were MSWC at 0, 25, 50, and 75% w/w; and sulphur at 0, 10 and 20 mg/pot mixed in Promix-BX peat moss soilless substrate. An increase in the rate of MSWC increased SPAD value for onion plant leaf greenness, anthocyanin content (up to 50%) and photosynthetic activity. Unlike the MSWC, S application and the interaction between S and MSWC had no significant ($P>0.05$) effect on onion plant growth and bulb yield components. Consistently, the 25% MSWC treatment significantly ($P < 0.01$) increased plant height, bulb diameter, number of fresh scale leaves and bulb fresh and dry weights. MSWC at ≥ 50% significantly ($P < 0.01$) reduced these growth and yield parameters. Total soluble solids (TSS) content of the onion bulb was significantly ($P < 0.01$) influenced by the applications of S and MSWC, and their interaction. The 25% MSWC and the 10 mg S pot−1 treatments gave the highest onion bulb tissue TSS content. The MSWC and the S applications increased the nutrients contents of the onion bulb tissue at harvest. In conclusion, MSWC amendment can be adopted to increase onion plant growth and plant tissue quality. Future studies should increase S rate and evaluate onion bulb flavor indices.

Seaweed Extract and Humic Acid Biostimulants Improve Growth and Postharvest Quality of Lettuce and Spinach (Poster Board #208)

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The leafy greens are highly perishable vegetables that are affected by preharvest and postharvest conditions. These vegetables generally have short shelf-life. Biostimulants can be utilized to enhance germination, growth, yield and quality of the crops. In this study, the effect of two plant biostimulants, Ascophyllum nodosum extract (ANE) and humic acid (HA) and their combinations (ANE+ HA) were evaluated for their potential to improve growth and minimize postharvest losses in lettuce and spinach. Thirteen combinations of ANE and humic acids were assessed for seed germination and early growth of lettuce and spinach. Among these, most effective treatments were used to analyze postharvest quality of lettuce and spinach. In the laboratory, the application of ANE, HA, and ANE+HA significantly ($P ≤ 0.05$) improved germination and early growth parameters of lettuce and spinach. The combination treatment, 0.25 % ANE and 0.2 % HA ($T_{0.2}$) showed103.2% and 13.1% increase in the radicle length of lettuce and spinach, respectively. Similarly, plumule length was also higher in the presence of ANE, HA, and ANE+HA. Under the greenhouse conditions the weekly application the
biostimulants improved biomass in all treatments but fresh and dry biomass in lettuce treated with 0.25% ANE and 0.2% HA (T12) were 103.1% and 113.9% respectively, compared with control. Whereas in spinach T12 had increased fresh and dry biomass by 62.9% and 103.3%, respectively. Preharvest treatment of lettuce and spinach with the combined ANE and HA significantly reduced fresh biomass loss during storage at 4 °C for up to 21 days. Further visual appearance quality (color, turgor and reduced softening of tissue) was also maintained while the nutritional quality of total antioxidants and phenolics were 1.7- and 1.5-fold, respectively, higher than the control. The preliminary results suggest ANE, HA and combination ANE + HA would enhance seed germination, plant growth and retain postharvest quality of lettuce and spinach.

**Effect of Sulfur Fertility on Proteins and Carbohydrates in Beans of Edamame Soybean [Glycine max (L.) Merrill]** (Poster Board #209)

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Edamame, a vegetable soybean [Glycine max (L.) Merr.] known for larger seeds or beans and sweet flavor, is harvested and consumed in the R6 growth stage prior to reaching full maturity. Consumers in the United States have increasing interest in edamame because of its protein content and beneficial health properties; however, the buttery flavor and crispy texture is responsible for the desirability with American consumers. Sulfur (S) is a component of the amino acids cysteine and methionine which are the building blocks of proteins, but also contributes to bitter flavors in many vegetable crops. Little is known about how S fertility influences protein and carbohydrate content in the beans of edamame. As result, a solution culture experiment was conducted to evaluate the effect of S fertility levels on protein and carbohydrate content in edamame beans. Seeds of 'Chiba' edamame were germinated under greenhouse conditions at 22 °C day/14°C night in Fall 2016. Fifteen days after germination, seedlings were transferred to twenty 30-L tubs holding five plants each and filled with a modified Hoagland's nutrient solution containing S treatment levels of 4, 8, 16, 32, and 64 mg L⁻¹ S. Sulfur treatments were delivered as magnesium sulfate (MgSO₄) and sodium sulfate (Na₂SO₄) to balance the other essential nutrients. Treatments were arranged in a randomized complete block design with four replications. Nutrient solutions were replaced to their original nutrient concentrations every 2 weeks and the photoperiod was reduced to 10 h on 8 Nov. 2016 to induce flowering. Plants were harvested approximately 60 days after planting when they reached the R6 maturity stage and weighed for fresh biomass. Fresh samples were either frozen at −20 °C for carbohydrate analysis or oven dried at 60 °C for protein content analysis. Elemental S concentrations were measured in oven-dried bean tissue using ICP-MS. Manipulating S fertility concentrations showed no significant effect on bean accumulation of crude protein (P = 0.171), adjusted protein (P = 0.171), acid detergent fiber-neutral protein (P = 0.409), acid detergent fiber dry matter (P = 0.707), or amylase neutral detergent fiber (P = 0.271). Edamame bean sucrose (P = 0.009) and fructose (P = 0.001) increased linearly in response to decreasing S fertility, but bean glucose (P = 0.416) levels were not affected. The results showed that increasing the S concentration from 4 to 64 mg L⁻¹ S in nutrient solution culture did not affect the protein composition in beans of ‘Chiba’ edamame, but did significantly affect bean carbohydrate levels.

*Specified Source(s) of Funding:* Illinois Soybean Association

**Pomology 3 (Poster)**

**Effect of Ripening Seasons on Nutrient Requirements of Peach Trees** (Poster Board #437)

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Peach trees from different ripening seasons may have distinct nutrient concentrations in the removed organs so they might lose different amounts of nutrients through nutrient removal events. The objective of this study was to determine the nutrient concentrations in organs removed from the tree (either as a consequence of orchard management practices or naturally). We used peach trees from different ripening seasons, and calculated the amount of removed nutrients among different cultivars. We selected 18 peach trees of six cultivars from three different ripening seasons (early-season: ‘Desiree’ and ‘Spring Snow’; middle-season: ‘Sweet N’Up’ and ‘Coralstar’; late-season: ‘Snow Gem’ and ‘Snow King’), and measured the nutrient concentrations in all the removed organs, including pruned wood, thinned fruitlets, harvested fruits and leaves fallen during autumn. Nutrient analyses showed that early-season cultivars accumulated i) more nitrogen in thinned fruitlets and mature fruits, ii) more potassium in pruned wood, mature fruits and fallen leaves, and iii) more phosphorus in mature fruits and fallen leaves compared to mid- and late-season cultivars. Early-season cultivars lost more nutrients through pruning and leaf fall but lost less nutrients through harvesting compared to mid and late-season cultivars. These results suggest that ripening season can affect peach tree nutrient requirements and fertilization with different levels of nutrients should be applied to the orchards instead of one uniform fertilization program. These findings are expected to help farmers to optimize fertilization plans that are specific to the ripening season of their peach trees.

*Specified Source(s) of Funding:* South Carolina peach council, Southern Region of SARE

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An asterisk (*) following a name indicates the presenting author.
Seasonal Nitrogen Dynamics in Young Peach Tree. Where Does the Nitrogen Go? (Poster Board #438)
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Nitrogen fertilization and irrigation are two essential management practices to achieve adequate plant growth and yield. For many years, the peach industry in the southeastern United States has been using fertilizer recommendations for young plants that are believed to be outdated and not well-suited to modern production practices. On the other hand, irrigation recommendations for young plants are non-existent, and irrigation is typically not used until three years after planting. We tested different fertilizer and irrigation rates from field planting, at the University of Georgia, with the objective of improving current recommendations for young plants. To complement that research and to improve our understanding of the seasonal nitrogen dynamics in orchards, we determined how different nitrogen rates and irrigation availability influence the amount of nitrogen being utilized by young peach plans. The amount of nitrogen removed by plant material during major management practices that affect plant growth (pruning, thinning, harvest, and defoliation) was quantified for the 2016 and 2017 seasons. ‘Julyprince’ plants grafted onto ‘Guardian’ rootstock were planted in 2015, at a density of 358 plants/hectare. Two irrigation rates (sensor-based irrigation at volumetric water content of 15-25% versus non-irrigated), two irrigation systems (drip versus micro-sprinkler), and four fertilizer rates (16, 33, 65, and 129 kg of N per hectare for one-year-old plants; and 23, 48, 95, and 191 kg of N per hectare for two-year-old plants) were tested. Plants growing in the highest fertilizer rate had 230 g of nitrogen removed by the management practices compared with ~205 g with the lowest fertilizer rates. Fall defoliation was where most of the nitrogen was allocated and removed from the system. Irrigated plants had more nitrogen removed through the management practices than non-irrigated plants (248 g versus 174 g per plant), with most of the nitrogen removed by defoliation and pruning. When comparing the irrigation systems, drip irrigation induced greater nitrogen removal than sprinkler irrigation (231 g versus 191 g per plant), mainly through defoliation. The results of this research are important indicators that when more nitrogen is applied, plants primarily allocated resources to produce vegetative structures, not affecting fruit yield if plant’s needs are met. Irrigation induces greater nitrogen absorption by the plant, resulting in greater vegetative and reproductive structures. Even with all these variations in nutrient allocations and removal, no nutritional deficiency was found across treatments.

Specified Source(s) of Funding: Peach Commodity Commission

High Tunnel Apricot Production in Frost Prone

Northern New Mexico (Poster Board #439)
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Late frosts are the number one issue challenging fruit production in northern New Mexico. The NMSU Alcalde Center had apricot trees for 15 years and no fruit was produced due to late frosts. There are native apricot trees in the communities with sporadic crops. Since 2012, we planted apricots in two 16 x 40 ft (9.5 ft high-point) high tunnels with spindle and upright fruiting offshoot (UFO) systems. There were five cultivars planted in each high tunnel at 4 x 8 ft spacing in a randomized complete-block design with two replications and two trees per cultivar in each plot. In 2015, Puget Gold had the highest yield (29.0 lb/tree) in spindle system while Golden Amber had the highest yield (18.6 lb/tree) for the UFO system. On average, UFO produced 60% of the yield of the spindle system in 2015. There were more lessons learned than success in this study. A heating device is mandatory in high tunnel apricot fruit production in northern New Mexico since trees normally bloom in early to late March depending on year while the frosts can continue until mid-May. Heaters should also have the auto-on and off function regulated by a thermostat. In years like 2017 and 2018 with temperature <−10°C in late February or early March, the expanded flower buds were killed before bloom. On those cold nights, one 100 lb tank of propane may or may not be enough for one night’s frost protection. Economically, it was not feasible. Only in years of cool spring and late blooming trees with mild April and May, the high tunnel apricot production can make positive revenue. High tunnel apricot production with heating device is still very risky and cannot guarantee a reliable crop each year in northern New Mexico.

Specified Source(s) of Funding: NIFA Hatch Grants

New Sweet Cherry Canopy Architectures Differ in Leaf Area at Maturity (Poster Board #440)
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Sweet cherry orchards have changed with the availability of precocious, highly productive, and vigor-controlling rootstocks such as the Gisela (Gi) series from Germany. These rootstocks have led to new ideas about the applicability of high density production systems to cherry orchards, resulting in new canopy training systems such as Tall Spindle Axe (TSA), Super Slender...
Salt Tolerance of Punica Granatum ‘Wonderful’
(Poster Board #441)

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Punica granatum ‘Wonderful’ (pomegranate) is currently the industry standard cultivar that accounts for over 90% of all commercial trees planted. Little research based information is available on its salt tolerance. Plants were pruned uniformly prior to treatments: irrigation with nutrient solution at an electrical conductivity (EC) at 1.2 dS·m⁻¹ (control), saline solutions at EC of 5.0 dS·m⁻¹ (EC 5) or 10.0 dS·m⁻¹ (EC 10). New growth, which was identifiable visually, was harvested eight weeks after treatment (first harvest). One week later, the same plants were received the same treatments for another eight weeks. The new shoot growth during the second eight-week treatment and roots were harvested (second harvest). Dry leaves, stems, and roots were ground, and samples were used for mineral nutrient analysis. At both harvest dates, all pomegranate plants had no or minimal foliar salt damage. At the first harvest, treatment EC 10 decreased the pomegranate shoot dry weight by 15%, but EC 5 did not. At the second harvest, treatment EC 5 and EC 10 reduced shoot dry weight by 13% and 31%, respectively. The sodium (Na) concentration in the leaf and stem tissue of ‘Wonderful’ pomegranate in all treatments was less than 1 mg g⁻¹ on a dry weight basis, while that in the root tissue was 0.8, 3.7, and 4.5 mg g⁻¹ in control, EC 5, and EC 10, respectively. The Cl content in leaf, stem, and root tissue increased by 36 to 90%, 101 to 156%, and 254 to 299%, respectively. These results indicate that ‘Wonderful’ pomegranate is very tolerant to the saline water irrigation in this study and has a strong capability to exclude Na and Cl accumulation in the leaf tissue to avoid salt damage.

Specified Source(s) of Funding: Hatch project TEX090450

Despite a General Warming Trend, Erratic Temperatures during Late Winter Eliminates Successive Peach Crops in North Florida
(Poster Board #442)

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A 0.5 ha peach orchard was established during March 2015 at the NFREC-Quincy. The cultivars and chilling units were as follows: Gulfking (350), Suncoast (375), Flordacrest (400), Flordaking (400), Gulfcrimson (400), GulfPrince (400), Gulfsnow (400), GulfAtlas (400) and Gulfcrest (525). Flordaking and Flordaking are melting flesh peaches, Suncoast is a melting flesh nectarine, and the remainder Gulf series are non-melting flesh peaches. The chill units recorded for 2016, 2017, and 2018 were 550, 350, and 625, respectively. Trees were 2.5–3.0 m tall and 2.3–2.8 m wide by the second leaf. Yield varied from 2–24 kg, and fruit weight varied from 60–118 g depending upon the cultivar. Freeze events occurred on 15 Mar. 2017, and on 9 and 15 Mar. 2018, virtually eliminating the entire peach crops. Trees were well passed full bloom, with the exception of ‘Gulfcrest’ in 2017 when the freeze events occurred. Thus, despite a general warming trend for winters during the last two decades, erratic winter temperatures remain a potential problem for the culture of peaches in north Florida.

Specified Source(s) of Funding: Florida Department of Food and Agriculture Specialty Crop Grant
A Study on Standardization and Distribution
Survey for Competitive Advantage of Gomchwi(Ligularia fischeri) (Poster Board #443)
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Ligularia fischeri production farmers have difficulty in determining the size of the product during the cultivation process and determining the packaging size. Because there is no survey on consumption situation and preferred sizes. On the other hand, consumers have difficulty in increasing consumption and satisfaction. Because their preferred size of product and packaging size are not available. By utilizing distribution information that examines Ligularia fischeri consumption situation and preferred packing sizes, producers can increase income and consumers can increase utility. The number of fresh leafy Ligularia fischeri purchases per household in the Seoul metropolitan area are 2.8 and the weight of the purchase is 4.3 kg. In 2016, purchase by sales place is as follows: direct transactions over the internet (46.8%), traditional market (21.3%), supermarket (12.8%), agricultural cooperative association (12.8%), and wholesale and retailer living cooperative association (6.3%). More than half of the purchase is direct deals. Therefore, it is advantageous for producers to increase direct transactions by active marketing online or offline. The preference according to the size of the product is as follows: 11–15 cm (43.3%), ≥ 16 cm (43.3%), 6–10 cm (11.1%), and ≤ 5 cm (3.3%). Most consumers buy 11–15 cm, 16 cm or larger. Depending on the consumer’s preference, the product size is concentrated at 11–15 cm, 16 cm or larger. The consumer’s willingness to purchase according to the size of the product is as follows: 11–15 cm (42.2%), ≥ 16 cm (32.2%), 6–10 cm (24.4%), ≤ 5 cm (1.1%). Consumers preferred 11–15 cm and then ≥ 16 cm. Consumer’s willingness to purchase is more than twice as the actual purchase at 6–10 cm. Therefore, a strategy to increase the 6–10 cm products is necessary. The consumption situation of certified products by Ligularia fischeri consumers is as follows: non-pesticide certified (54.8%), organic agricultural products certified (9.7%), GAP certified (4.5%). There is a high preference for certified products. Therefore, it is advantageous for producers to receive various certifications. The preference of packaging materials for the Ligularia fischeri consumers is as follows: paper box (73.4%), plastic (23.4%), the rest (3.3%). Most consumers prefer paper-box packaging products. The purchase conditions by weight are as follows: 1 kg (61.3%), 500 g (10.7%), 2 kg (9.7%), 200 g (7.5%), 4 kg (7.5%), and 300 g (3.2%). Consumers usually prefer a 1 kg package. Ligularia fischeri consumers’ willingness to purchase by weight of product is as follows: 1 kg (57.8%), < 1 kg (26.7%), > 1 kg (15.6%). The demand for < 1 kg is 26.7%. Therefore, it is necessary to sell small packages of various sizes. According to the survey, producers need a strategy to reduce the size of products 16 cm or larger by more than 10% and to increase the volume of less than 1 kg.

Yield and Storability of Open-pollinated and Hybrid Onions in Chile (Poster Board #241)
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Onion is the second most important vegetable in Chile. Production for export or storage is based in a small number of long-day open-pollinated (OP) cultivars. During the last decade many hybrid cultivars asserting to have superior yield and bulb quality have been introduced. The lack of objective information regarding the performance of these new hybrid cultivars under Chilean conditions, posed the main objectives of these studies: to compare yield and storability of available onion cultivars in Chile. During the 2014–2015 season two trials were conducted in different locations: Malloa (34°27’S, 70°57’W) and Chépica (34°44’S, 70°15’W). In each location, 16 cultivars were produced; 10 of them were hybrid and 6 of them were OP, including the most used OP cultivar, Cobra, as control. For each cultivar, harvest was performed when around 50% of the plants foliage lodged. After bulbs weight and diameter were registered, they were cured and stored in well ventilated rooms (12, 5 °C average temperature; 77, 5% average relative humidity). Bulb losses due to sprouting or rotting were determined every two weeks. In Malloa yield ranged between 9.9 and 1.7 kg/m² while in Chépica ranged between 9.0 and 3.2 kg/m². In Malloa, Cobra out performed most of cultivars but there were two hybrids that had higher yields (non-significant difference). In Chépica, two hybrids had higher yields than ‘Cobra’ (P < 0.05). In addition to their good yield, some of the hybrids stood out for their high bulb quality (uniformity, size and high percentage of single centers). When stored, Cobra and three other OP cultivars had greater resistance to sprouting than most of hybrids. In bulbs produced in Malloa, after 245 days of storage ‘Cobra’ presented 14% of bulbs sprouted while most of hybrids had over 40% sprouting. In onions produced in Chépica, after 223 days of storage, ‘Cobra’ presented 30% sprouting and most of hybrids had over 50% sprouting. In summary, results highlight the importance of cultivar evaluation and selection in onion productivity. Some of the new hybrid cultivars that are been introduced in Chile presented competitive yields and quality, however it lower resistance to sprouting during storage should be considered.

Use of Maleic Haizide for Sprouting Inhibition during Storage of Open-pollinated and Hybrid Onions (Poster Board #242)
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Cobra and Hybrid Onions
Inhibition during Storage of Open-pollinated
Yield and Storability of Open-pollinated and
Hybrid Onions in Chile
Poster Presentations

Poster Presentations
In Chile, onion production is mostly based on long-day cultivars, which are harvested during summer, stored, and marketed from autumn to early spring. The open-pollinated (OP) cultivars that have been traditionally used have good resistance to bulb sprouting; hybrids with competitive yields and high quality bulbs but lower resistance to sprouting have been introduced in recent years. The objectives of these experiments were to determine the timing and outcome of maleic hydrazide (MH) treatments to inhibit bulb sprouting. Two experiments were conducted, in 2015 (Exp. 1) and 2016 (Exp. 2). In Exp. 1, MH was applied to cultivars Cobra (OP) and Pandero (hybrid) 2, 9, and 16, and 23 days before harvest (DBH). Effects of MH treatments were compared with a non-treated control of each cultivar. In Exp. 2, the effect of HM applied 15 DBH was compared with non-treated bulbs of cultivars Cobra and Titan (hybrid). Storage of bulbs in both experiments was carried out in similar conditions to those traditionally used by local growers (ambient temperature, 12.5 °C average, and 77.5% average relative humidity). Results from Exp. 1 showed that HM treatments did not have any effect on bulb yield or size. Non-treated bulbs of ‘Cobra’ presented 11 and 53% sprouting after 204 and 245 days of storage, while non-treated bulbs of ‘Pandero’ had 39 and 94% sprouting after the same period of storage. In both cultivars, sprouting of bulbs treated with HM 2 DBH was similar with non-treated bulbs, while the use of HM 16 or 23 DBH reduced sprouting around 50% compared to non-treated bulbs; bulbs treated with HM 9 DBH had an intermediate response. In Exp. 2, after 199 and 245 days of storage, non-treated bulbs of ‘Cobra’ had 22 and 58% sprouting, and non-treated bulbs of ‘Titán’ had 63 and 86% sprouting. The HM treatment had a positive effect in ‘Cobra’, reducing sprouting in around 60% compared with non-treated bulbs; in ‘Titán’ the effect was even greater, reducing sprouting more than 90%. In conclusion, HM treatment of plants two weeks before bulb harvest had a positive effect in reducing the sprouting of bulbs during storage. For Chilean growers, the use of HM would be specially recommended when using new hybrid onion cultivars, which have shown to have higher susceptibility to bulb sprouting during storage than traditional OP cultivars.

Genome-wide Association Mapping of Deterioration in Fresh-cut Lettuce

(Joint Board #243)

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Fresh-cut lettuce is widely used in packaged leafy vegetable salads. While there are no current estimates of the retail value of fresh-cut lettuce, the segment represents 25 to 35% of raw product production in Monterey county of California, which has a farm gate value of approximately 1.5 billion dollars. Most fresh-cut products involve harvesting whole mature heads of romaine or iceberg type lettuce, cutting the leaves to a specified size, and packaging the salad in clear specialized films with modified atmospheres (modified atmosphere packaging, MAP). However, even in MAP, fresh-cut lettuce can have short shelf life and deterioration can occur within a week after processing. Deteriorated lettuce is not marketable, must be disposed, and results in the need for more lettuce to be grown, processed, and transported. Lettuce cultivars with extended shelf life will help reduce waste and increase efficiency. Genome-wide association studies (GWAS) were performed on a set of 498 lettuce accessions. The accessions were genotyped, and 4615 high-quality, polymorphic, single-nucleotide polymorphism (SNP) markers were used for analyses. For shelf life assessment, four field experiments were performed in three locations in Salinas Valley during 2016 and 2017. Lettuce heads were harvested, processed into fresh-cut salad, and stored at 4 °C for evaluations. Salad bags were visually evaluated weekly and deterioration assessed using the scale of 0–10, where the rating corresponds to 1/10th of the estimated percentage of deteriorated tissue. Mean area under deterioration progress stairs (AUDepS) was calculated for each accession. GWAS of shelf life data was performed by mixed linear model analyses; the genetic relationships among the individuals were incorporated into statistical models using principal component analysis and kinship matrix. Significant marker-trait associations (SMTA) were detected on Linkage Group 4 (LG4) in all experiments. The most significant P-value was 8.44E-14 that explained 15% of the total phenotypic variation (R² = 0.15) of the trait. Major quantitative trait loci (QTL) for deterioration of fresh-cut lettuce were reported previously in LG4 in a recombinant inbred line population of ‘Salinas 88’ × ‘La Brillante’. Molecular markers closely linked with the trait QTL can be applied for selecting lettuce genotypes with a slow rate of deterioration and for identification of gene(s) responsible for extended shelf life of fresh-cut lettuce.

Influence of Artificial Bacterial Inoculation on Enzymatic Browning of Fresh-cut Potatoes and Apples

(Poster Board #244)

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We have found higher bacterial counts on fresh-cut potatoes and apples with wound-induced enzymatic browning tissues than non-browning tissues. Bacterial species isolated only from the browning tissues were identified as Pseudomonas fluorescens on potatoes and Herbaspirillum huttiense on apples. In this study, we investigated the influence of inoculation with P. fluorescens
and *H. hutiense* on the browning response of fresh-cut potatoes and apples, respectively. Surface color, enzymatic activities of polyphenol oxidase (PPO) and peroxidase (POD), amounts of phenolic compounds and lignin, and bacterial counts were determined in sliced potatoes inoculated with *P. fluorescense* and sliced apples inoculated with *H. hutiense* (approximately 3 and 6 log CFU/mL) during storage for 3 days at 5 °C. Non-inoculated fresh-cuts were used as the controls. When fresh-cut potatoes were initially inoculated with either 3 or 6 log CFU/mL of *P. fluorescense* and then stored, bacterial counts increased from an initial 3.0 log CFU/g to 5.3 log CFU/g to 5.7 log CFU/g or 8.2 log CFU/g, respectively, after 3 days of storage. However, no differences were found in the surface color, activities of PPO and POD, amounts of phenolics and lignin between non-inoculated and inoculated fresh-cut potatoes regardless of the inoculum levels. With fresh-cut apples, bacterial counts increased to 5.1 log CFU/g following inoculation with 6 log CFU/mL of *H. hutiense* and the counts were constant during storage for 3 days. In comparison, the bacterial counts of fresh-cut apples either uninoculated or inoculated with 3 log CFU/mL were below the detection level (2.4 log CFU/g) throughout the storage period. Inoculation did not affect surface browning, activities of the enzymes, and amounts of the components during storage, except that the polyphenol content was higher in non-inoculated samples than inoculated samples. These results indicated that artificial inoculation with *P. fluorescense* and *H. hutiense* did not enhance browning of fresh-cut potatoes and apples with the accumulation of phenolic compounds and lignification, although we have hypothesized that the bacteria could synthesize bacterial PPO or POD resulting in the browning enhancement.

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**Preharvest UV-B Irradiation Elevates Glucosinolate Contents and Improves Postharvest Quality of Broccoli Microgreen** *(Poster Board #245)*

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Many recent studies report that broccoli has great anti-cancer activities because of high glucosinolates (GLs) contents, such as glucoraphanin (GLR) and glucoerucin (GLE). Previously we showed that broccoli microgreen contains high GLs than broccoli florets and mature leaves, indicating that microgreens are a richer source of GLs than mature broccoli. Preharvest calcium spray could significantly increase the total aliphatic GLs levels, while postharvest ultraviolet-B (UV-B) radiation only has limited effects on GLs enrichment. Here we report the impact of preharvest ultraviolet UV-B treatment on GLs levels in broccoli microgreens. Our results showed that preharvest UV-B treatments with 10 mM CaCl$_2$ spray could significantly increase the GLE, GLR, and total aliphatic GLs levels by around 70% in broccoli microgreens as compared to the control. Additionally, our results showed that preharvest UV-B treatment together with calcium spray could significantly increase the total aliphatic GLs contents in broccoli microgreens. The nutritional qualities of two UV-B treated microgreens were quite stable during 21-day storage, with only small changes in their GLS levels. The UV 0.27 Wh/m$^2$ with 10 mM CaCl$_2$ spray treated broccoli microgreen maintained their overall quality, and had the lowest TEL and off-odor values during the storage. Furthermore, UV-B 0.27 Wh/m$^2$ treated microgreens significantly upregulated the level of GLs synthetic genes such as CYP79F1 during storage. Thus, the preharvest UV-B is more effective on enriching the GLs levels than postharvest UV-B. Overall, preharvest UV treatment together with calcium spray can enhance the health-beneficial compounds and improve the postharvest quality of broccoli microgreen.

**Storage Temperature and Time Impacts Glucosinolates and Flavor Volatiles of Broccoli Grown on the East Coast** *(Poster Board #246)*

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East Coast broccoli production decreases the time between harvest and purchase for East Coast consumers. The objective of this experiment was to monitor the effect of storage temperature and time on broccoli grown on the East Coast. A randomized complete block design was conducted using two broccoli varieties (Emerald Crown and Diplomat) obtained from a local grower. At harvest, broccoli was sorted into containers to establish four replications each of two storage conditions: 0 °C (iced at harvest) and 5 °C (cooled in storage). Broccoli heads of each variety were sampled weekly for seven weeks during postharvest storage, including the day of harvest. Florets were freeze-dried, ground, and analyzed for 13 glucosinolates, which included glucoraphanin (detrimental to health), glucoerucin, glucoraphanin and glucobrassicin (anti-carcinogenic properties), and total glucosinolate content. A complete volatile profile was analyzed using the fresh frozen tissue. Volatiles reported are dimethylsulfide as an indicator of off-flavor volatiles, and 2-ethyl-furan, benzeneacetaldehyde, and 2-pentyl-furan as indicators of desirable flavor volatiles. Data were analyzed using mixed model analysis of variance (Glimmix procedure, SAS Institute, Cary, NC). Glucoraphanin was essentially undetectable in Diplomat broccoli and was greater in Emerald Crown broccoli stored at 0 °C ($P<0.05$). Glucoiberin, glucoerucin, and glucoraphanin were found in significantly greater quantities in
both cultivars stored at 0 °C (P < 0.05) compared to storage at 5 °C. Glucoiberin was 59% greater in Emerald Crown than Diplomat broccoli (P < 0.0001). Overall, broccoli stored at 0 °C had greater total glucosinolate content (P=0.0001). Dimethylsulfide was greater in Diplomat broccoli (P = 0.0007), broccoli stored at 5 °C (P < 0.0001), and at 42 days postharvest (P < 0.0001). 2-ethyl-furan and 2-pentyl-furan were both greater in broccoli stored at 0 °C (P < 0.01) and at the day of harvest compared to all other days (P < 0.0001). However, Emerald crown had greater concentrations of 2-ethyl-furan (P = 0.0003), while Diplomat had greater concentrations of 2-pentyl-furan (P = 0.0006). Benzenecacetaldehyde was greater in broccoli stored at 0 °C for both varieties (P = 0.012). Neither storage temperature nor time greatly affected nutritionally harmful glucosinolates. However, both cultivars of broccoli stored at 0 °C had a higher concentration of anti-carcinogenic glucosinolates. As time and temperature increased, undesirable flavor volatiles increased and desirable volatiles decreased. This study indicates that storing broccoli at 0 °C for no longer than 21 days is optimum to maintain the quality of desirable volatiles and anti-carcinogenic glucosinolates. Future experiments are needed to evaluate a broader range of postharvest temperatures for impact on these and other quality parameters.

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**Microencapsulation and Antimicrobial Activity of Carvacrol in a Pectin–Alginate Matrix**

(Poster Board #247)

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Carvacrol is a natural phenolic compound that has received great attention due to its high antimicrobial activity. However, the applications of this compound are limited for its high volatility and low water solubility. In this research, the use of food grade polymers for microencapsulation of carvacrol in a pectin-alginate matrix using spray drying method was studied. The physical properties, encapsulation efficiency, stability, and the microstructure of the microcapsules were analyzed as well as the products’ antimicrobial and antioxidant properties. The microcapsules were regularly spherical particles with 4.51% moisture content, 0.33 g/cm³ bulk density, 4.55 min wettability, and a hygroscopicity at 34.44 g water absorbed/100 g powder. The microcapsules also showed high encapsulation efficiency (76.98%) and stability. The microencapsulation process did not significantly affect the antimicrobial activity against *Escherichia coli* K12 (minimum inhibitory concentration (MIC) = 0.25 mg/mL) and antioxidant activity (DPPH percentage inhibition (PI) = 89.96%) of carvacrol. The results indicated that the microcapsules may have important applications in postharvest for the protection of fruit and vegetables from microbial contamination. It may also be suitable for the application in foods and nutraceuticals processing industry.

**Catechin and Volatile Compounds in Oolong Tea under Vibrating Stimulus** (Poster Board #248)

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Tea [*Camellia sinensis* (L.) Kuntze] offers great benefit to human health and it is the second most popular drink, only eclipsed by water. Oolong tea is popular to consumers because of its unique flavor. The formation of Oolong tea flavor derived from its special processing, especially the shaking procedure that induced the flavor of Oolong tea by mechanical force. We applied the same *Tieguanyin* withered leaves as material, provided continuous vibrating stimulus to tea leaves as treatment with natural spreading as control, and collected samples continuously during the vibrating. Catechin composition and content were analyzed by LC-MS and the content of volatiles by GC-MS. The results indicated that catechin composition in the vibrating tea leaves were lower than natural spreading. There were significant differences among vibrating time. For volatiles, the relative percentage of alcohols, aldehydes and esters was at 14.75%, 5.29%, and 4.34% respectively, higher than that of the control after vibrating five minutes. The ketone was higher in the period of 30–90 minutes, up to 20.41%. The hydrocarbon was up to the peak of 12.95% at 120 minutes. The phenylacetone was higher in 30–90 minutes with the highest of 20.20%. Linalool and salicylate were higher after five minutes, up to 1.82% and 2.22%. Both nerolidol and indole were higher at 120 minutes, up to 1.06% and 2.81%. With decreasing of catechin content by vibrating stimulus, the bitterness of tea soup reduced and the Oolong tea had a much smooth and pleasant taste. Vibrating stimulus increased volatiles at the important stages, which provided basic material for the flavor formation of Oolong tea and eventually resulted the unique quality of Oolong tea.

Specified Source(s) of Funding: National “20th 5-year” S&T
Seasonal Changes in Polar Lipids Linked to Needle Abscission in Four Genotypes of Balsam Fir Postharvest (Poster Board #249)

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Several studies have suggested that postharvest needle retention in balsam fir (Abies balsamea L.) increases in autumn due to cold acclimation, and that this is more evident in genotypes with lower postharvest needle retention prior to cold acclimation. It has been found that many changes occur in balsam fir during autumn months, such as accumulation of ABA, raffinose, and galactose. However, the possible roles of lipids and fatty acids (FA) in postharvest needle abscission have not been confirmed. The objective of this study was to identify if changes in polar lipids occur and if these changes are related to postharvest needle abscission in balsam fir. An additional objective was to identify any genotypic differences. Four genotypes of balsam fir, AB-NSD-016, AB-NSD-005, AB-NSD-140, and AB-NSD-124, were sampled (x5) in the clonal orchard owned by the Department of Natural Resources, Debert, Nova Scotia, Canada at 5 time periods between September and February. Onsite testing was performed for capacitance, fluorescence, and membrane injury (MII). Samples were frozen in liquid nitrogen to store in a –80 °C freezer for later polar lipid and fatty acid analysis.

The weather and photoperiod parameters were collected from the Environment Canada Weather Station located within a 2 km radius of the orchard. In addition, “sister” branches (x5) were collected at each sampling interval, transferred to the lab and hydrated to determine the mean needle abscission commencement (NAC), and average daily water usage (ADWU). The experiment was designed as a 4 × 5 factorial and analyzed using repeated measures. AB-NSD-016, AB-NSD-005, AB-NSD-140, and AB-NSD-124 had a mean NAC of 42, 52, 32, and 75 days, respectively. AB-NSD-124 had significantly better needle retention than all other genotypes in each of the sampling periods (P = 0.000). The poorest needle abscission resistance (NAR) was the genotype AB-NSD-124. All genotypes commenced needle abscission significantly earlier when collected in February than collected in September through December (P = 0.000), possibly related to a January thaw. Fluorescence was significantly (P < 0.05) linked with Tmin, (r = 0.881), a typical response to winter stress and reduced photosynthesis. With respect to polar lipids, there was no loss of lipids, but a redistribution of lipids as a result of exposure to decreasing temperatures and photoperiod. There was a significant (P < 0.05) decrease in the monogalactosyldiacylglycerol to digalactosyldiacylglycerol ratio (MGDG:DGDG). There were significant changes (P < 0.05) in four lipid species causing the change in the ratio: DGDG 36:6, MGDG 36:5, MGDG 36:6, and MGDG 36:7, the first two increasing and the latter two decreasing. There was an increase in the % of phosphatidylcholine (PC) and phosphatidyl ethanolamine (PE). These changes provide evidence that cold acclimation linked to lipid changes is occurring in these genotypes of balsam fir. However, there is not enough evidence to link these changes to postharvest needle abscission.

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Physiological and Molecular Characterization of Ethylene Binding and Biosynthesis Inhibition in Rosa Hybrida L. (Poster Board #250)
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In cut roses, the primary factors determining the longevity vary depending on flower sensitivity to ethylene. While the vase life of ethylene-sensitive cultivars is shortened by water stress, that of ethylene-insensitive cultivars is strongly related to ethylene synthesis. In this study, we characterized the nature of the ethylene sensitivity changes in four rose cultivars, which have different sensitivities to the hormone. In addition, we determined the impacts of ethylene binding and synthesis inhibition on flower senescence and gene expression using 1-methylcyclopropene (1-MCP) and aminoethoxyvinylglycine (AVG). Cut roses were treated either singly with 1 μL·L⁻¹ 1-MCP (+M) or simultaneously with 1 mM AVG and 1-MCP (A+M) for 12 h. After +M or A+M treatments, the flowers were subsequently exposed to ethylene. The relationship between the mRNA levels of ethylene biosynthesis, receptor, and signaling genes and the degree of ethylene sensitivity were determined during flower development and senescence. The results showed that A+M effectively maintained chlorophyll fluorescence emission (Fv/Fm) levels and water balance, and consequently prolonged the vase life of cut flowers in both ethylene-sensitive and -insensitive cultivars. In contrast, the cut flowers treated only with ethylene showed an early failure of water relations and shorter vase life. Both +M and A+M suppressed the expression of ethylene biosynthesis (RhACS2 and RhACO1) and receptor genes (RhETR1-5) in cut roses, although A+M was more efficient than +M. The expression of RhCTR1 and RhCTR2 was not consistently influenced by ethylene, however, was enhanced by +M and A+M. We also observed that the mRNA levels of RhEIN3-1, RhEIN3-2, and RhEIN3-3 were highly reduced by +M and A+M in ethylene-sensitive cultivars. These results contribute to better understanding about the relation between flower senescence and ethylene sensitivity changes in cut roses.
Vegetable Crops Management 2 (Poster)

Management of Intercropped Strawberry, Pepper, Eggplant, and Cantaloupe to Maximize Yield and Economic Return (Poster Board #015)

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Strawberry growers in the Southeast face rising production costs combined with competition from foreign markets and low commodity prices. These issues are especially important for growers that rely solely on the strawberry crop. Planting a vegetable crop on the same bed before strawberry crop termination enables continued berry harvest while the new vegetable transplants become established. This practice helps growers diversify, reduce risk, and increase profits. A study on relay cropping of strawberry with peppers, eggplants, and cantaloupes was done in Fall 2016 and Spring 2017 at GCREC, Balm, FL. The strawberries were planted in September, and the vegetables were transplanted on the beds with strawberry plants and as sole crops at five different dates (4 Jan., 18 Jan., 1 Feb., 15 Feb., and 1 Mar.). The objective of the research was to determine the competition between two crops and to optimize the efficient planting date of vegetables so as there will be a minimum effect on yield of both the crops. Data on yield and heights were collected. Strawberry yields did not differ between treatments regarding weight and counts. Pepper yield varied with transplant date but not the date of strawberry removal. The early planting dates (4 Jan., 21 Jan., and 1 Feb.) had significantly higher yields than later planting dates. The eggplant yields were not affected when planted with or without strawberries. The highest yields were obtained at the earliest planting dates (1 Jan. and 21 Jan.). The cantaloupes exhibited the same results as peppers; mid planting dates were higher yielding than others. In conclusion, the intercropping did not affect the yield of the vegetables. However, it differs with canopy structure and stature of the plant. The mid planting dates are better to transplant vegetables in strawberries to get high total yields. The strawberry yields were not affected by the vegetable intercropping which implies that the relay cropping could be the best practice to maximize the returns and minimize the yield losses.

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Effect of Antitranspirant Application on the Survival of Splice Grafted Watermelon (Poster Board #016)

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The production of grafted watermelon seedlings is labor-intensive and more costly to the propagator and grower than non-grafted seedlings. Rootstock regrowth, sometimes referred to as ‘suckering’, is a major concern for grafted watermelon as the commonly used grafting methods, one-cotyledon and hole insertion, often leave rootstock bud meristem tissue intact. Rootstock regrowth can result in scion abortion, graft failure, or a decrease in yield by robbing the scion of water and nutrients. Another challenge facing the watermelon grafting industry is grafting efficiency, especially the speed at which grafting occurs. Further, desiccation of the grafted seedling occurs because of water stress of the scion during healing and hardening after grafting, causing death of grafted seedlings. In this study, the splice grafting method was used where both rootstock cotyledons were removed to eliminate meristem tissue and rootstock regrowth. Antitranspirant products, which can increase stomatal resistance and mitigate water stress, were tested to determine if they could increase the survival of splice-grafted watermelon as compared to water control. Antitranspirant products Chitosan (0.08% solution), Root-Drench (2% solution), Moisture-Loc (10% solution) and Glycerin (4% solution) were applied as a drench or foliar spray to rootstock and scion seedlings 1 day before grafting. Survival (%) of splice-grafted watermelon seedlings 16 days after grafting was the greatest for plants that received Root drench and Glycerin treatment (70% and 57%, respectively), and was lowest for plants that received water (8%) (P = 0.0005). These results indicate that antitranspirant applications to rootstock and scion seedlings before grafting can increase grafting success, but further research is needed to optimize the environmental conditions for the survival of grafted plants.

Keywords: grafting efficacy, rootstock regrowth, transpiration, stomatal resistance

The Effect of Number of Lateral Shoots on Growth and Fruit Yield in Winter-planted Cultivation of Paprika (Capsicum annum L. ‘Redwing’) (Poster Board #018)

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This experiment was carried out to investigate the effect of number of lateral shoots on growth and yield according to the external weather conditions during the growing stage. The test group was divided into zero, one, two and three leaves of lateral shoots based on one leaf on main branch from 31 Mar.
2017 Muskmelon Variety Trial at Highmoor Farm, Monmouth, Maine (Poster Board #019)

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Melons were among the crops requested for trialing by members of the Maine Vegetable and Small Fruit Growers Association at the 2017 Maine Agricultural Tradeshow. A variety trial was designed at the University of Maine Agricultural and Forestry Experiment Station: Highmoor Farm in Monmouth Maine for the 2017 growing season. Thirty-two cultivars of muskmelon including cantaloupe, honeydew, galia, canary, crenshaw, and butterscotch types were planted in a random complete block design with four replications. Melons were seeded on 17 May and 25 May into 2” peat pots and grown in a greenhouse until they were moved into a high tunnel to harden off prior to transplanting. On 7 June, the melons were planted through black plastic in rows 8” on center with an in-row plant spacing of 18”. Melon yields were good at Highmoor farm in the 2017 growing season despite low rainfall amounts. For season yields, medium sized ‘Majus’ and ‘Wrangler’ (both Tuscan type cantaloupes) had high fruit numbers, high total plot weights and good flavor. Larger cantaloupes ‘Afterglow’, ‘Grand Slam’, ‘Athena’, and ‘Avatar’ had high fruit numbers and plot yields and had a harvest window of over 2 weeks. ‘Sarah’s Choice’ produced poorly, exhibited poor netting and worse flavor compared to the other cantaloupes trialed. ‘Minerva’ while having good flavor and a high brix reading, was very large. Melons with larger sizes may be unappealing to consumers who want a more manageable size fruit; or hard to package if shipping. Furthermore, melons that are small compared to their bigger counterparts may have similar edible flesh amounts. Honey dews are typically later than other melons and cooler late summer night time temperatures slowed the ripening process. This trial was terminated before all the honey dews ripened.

Evaluating USDA NPGS Cucurbit Germplasm Accessions for Resistance to Verticillium Wilt (Poster Board #020)

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Verticillium dahliae is a soil-borne fungal pathogen that causes Verticillium wilt. Grafting has been widely used as part of an integrated disease management strategy for Verticillium wilt in cucurbits. Cucurbit rootstock seeds can be expensive and seeds of most rootstock cultivars are imported into the United States from seed companies that breed them. Verticillium resistant germplasm accessions from the USDA National Plant Germplasm System (NPGS) could potentially be used by researchers and seed companies as rootstocks or as parents in rootstock breeding programs to develop domestic rootstocks. NPGS accessions could thus reduce the cost of development and availability of rootstock seed. This study evaluated 56 NPGS cucurbit accessions from four species – Benincasa hispida, Cucurbita maxima, Cucurbita moschata and Lagenaria siceraria — for their resistance to Verticillium wilt. These four species are commonly used as rootstocks for watermelon. The evaluation was done at WSU Mount Vernon NWREC, in a certified organic field naturally infested with V. dahliae (10 cfu g⁻¹ of soil). Seedlings were raised in the greenhouse and inoculated with V. dahliae microsclerotia (sand inoculum was adjusted to deliver 1.5 cfu per planting hole) at transplanting. Disease development was noted over five weeks, and AUDPC values were calculated for all accessions. Mean AUDPC values for germplasm accessions ranged from 9 to 297 and was 275 for ‘Sugar Baby’ (Verticillium susceptible control). Thirteen accessions with the lowest AUDPC values and no detectable V. dahliae colonies in a subsequent stem sap assays were identified. The selected accessions included L. siceraria (seven accessions) Lagenaria sp. (one accession) and Cucurbita (five accessions). These accessions will be used in a follow-up study, during which they will be used as rootstock for grafting watermelon and evaluated again for resistance to V. dahliae and grafting compatibility.

Summer Production of Broccoli in Western North Carolina (Poster Board #021)

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The Eastern Broccoli Project, a multi-state federally funded project led by Cornell University, includes researchers, extension personnel, public and private breeders, and farmers from
Maine to Florida in its efforts to create a broccoli (Brassica oleracea var. botrytis) industry in the eastern United States. An important aspect of the project is to try to extend the production season up and down the east coast across as many months of the year as possible. Producing this cool season vegetable in the summer is difficult for much of the East Coast. It can be done successfully in the New England region to satisfy market demand in the Northeast, but it is desirable to identify a more southern location to supply the Southeast. The high elevations in western North Carolina experience cooler temperatures during the late spring and summer than are commonly found in the Southeast. Our role in this project is to evaluate varieties, breeding lines, and cultural practices for summer production in the mountains of western North Carolina. Early in the project (2010–14), broccoli yields and quality from our research station and on-farm trials were low compared to those produced by our project colleagues in Maine, New York, Virginia, and South Carolina. Identification of heat tolerant varieties and breeding lines, use of raised beds and drip-irrigation, use of black plastic mulch in the early spring and white on black plastic mulch in late spring, increased plant populations, and improved transplant production have resulted in increased yields and quality. In the first five years of the project, five new varieties were released or marketed to the East, and improved selections particular for our region were identified. In our 2017 on-farm trials anparse an industry standard, Emerald Crown, and an advanced breeding line provided favorable marketing potential (approx. 49,421 heads/ha) over a good harvest window.

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Optimum Plant Spacing for New Mexico Green Chile (Capsicum annuum) Mechanical Harvest Efficiency (Poster Board #022)

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Closer plant spacing influences the plant growth habit of New Mexico chile by creating taller plants with fewer basal branches and higher fruit set. These traits are beneficial to mechanical harvest efficiency. Experiments conducted in 2015 and 2016 at New Mexico State University’s Los Lunas Agricultural Science Center investigated the impact of thinning NM green chile plants to 4- and 8-inch spacing on mechanical harvest efficiency, and if closer plant spacing would adversely affect green chile fruit size. Two commercial New Mexico green chile cultivars, ‘NuMex Joe E. Parker’ (Biad Chili Company, Las Cruces, NM) and ‘AZ-1904’ (Curry Chile and Seed Company, Pearce, AZ), were direct seeded on 17 Apr. 2015, and 14 Apr. 2016. Three thinning treatments (4, 8, and 12 inch plant spacing) were established in a randomized complete-block design with five replications. Plots were thinned on 11 Jun. 2015 and 14 Jun. 2016. The field was flood irrigated, fertilized and cultivated as needed. Plant measurements including height and width, height to main bifurcation, stem diameter, and number of basal branches were recorded immediately before harvest. An Etgar Series MOSES 1010 (Bet-Lehem-Haglilit, Israel) was used to mechanically harvest the plots on 2 Sept. 2015, and 31 Aug. 2016. Harvested material was sorted and weighed by marketable green fruit, broken fruit, and non-fruit plant material. Weight of fruit dropped on the ground and fruit left on the plants following harvest was also measured. Fruit dimensions (weight, width, length, and wall thickness) from a subsample of the harvested pods were recorded. Results were similar in both years. Overall, ‘NuMex Joe E. Parker’ provided higher mechanically harvested green chile fruit yield than ‘AZ-1904’. ‘NuMex Joe E. Parker’ with the 4 inch thinning had the most marketable green yield of 28,160 lb/acre, 101.4% more than the lowest yielding ‘AZ-1904’ with the 12 inch thinning. ‘AZ-1904’ fruit from the 4 inch thinning was significantly longer (22.6 cm) and heavier (112.6 gm) when compared to all ‘NuMex Joe E. Parker’ and ‘AZ-1904’8- and 12-inch thinning treatments. Fruit width and number of locules were not affected by thinning treatments. ‘NuMex Joe E. Parker’ at the 4 inch thinning had the tallest plants (73.9 cm) and also had the highest height to bifurcation at the 4- and 8-inch thinning treatments, 23.3 cm and 23.6 cm respectively. Both cultivars had a higher bifurcation value as the spacing between plants decreased.

Southeastern U.S. Brussels Sprout Variety Trial

(Poster Board #023)

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The Brussel sprout (Brassica oleracea var. gemmifera) is a cool season Cole crop in the mustard family. Sprouts, resembling small cabbage heads, develop along the leaf axil, maturing from ground level upwards. The majority of U.S. Brussels sprouts are produced in California. However, Brussels sprout popularity continues to rise in the Southeastern United States. In Louisiana and South Carolina, small scale vegetable producers are planting small plots of Brussels sprouts (less than 0.25 acres) for high end restaurants, grocery stores and farmers market consumers. A replicated variety trial was conducted in Husser, LA, and Charleston, SC, to determine if particular...
varieties would perform well in the fall season in warm humid states. Twenty-one varieties were initially selected, but because of low seed germination and poor performance in the field, the study was narrowed to 12 varieties. Total number of buds per plant, average bud diameter and total bud weight per plant were measured. Combining data from both states, ‘Hestia’ produced heavier total bud weight than all tested varieties. ‘Hestia’ also produced higher number of buds than ‘Dagan’, ‘Franklin’ and ‘Colbus’, and had wider bud diameter than ‘Colbus’, ‘Nautic’, and ‘Diablo’. Separating variety performance by state, ‘Hestia’ grown in Louisiana produced the least total number of buds, ranked average in bud weight, and was among the top varieties for bud diameter. South Carolina grown ‘Hestia’ ranked in the top two varieties for bud number, bud weight and bud diameter.

**Effects of Planting Date and Grafting with Interspecific Cucurbita Rootstocks on Seedless Watermelon Production** *(Poster Board #024)*

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In addition to Fusarium wilt resistance, the interspecific hybrid squash rootstock *(Cucurbita maxima × C. moschata)* is also known for its tolerance to low temperatures. This field experiment was conducted at the Suwannee Valley Agricultural Extension Center in Live Oak, FL, to explore the impacts of grafting with interspecific *Cucurbita* rootstocks on seedless watermelon yield and fruit quality at two planting dates during the Spring 2017 season. Seedless watermelon ‘Melody’ was grafted onto two interspecific *Cucurbita* rootstocks ‘Carnivor’ and ‘Super Shintosa’, respectively, with non-grafted ‘Melody’ as the control. Two types of grafted plants were also included, i.e., plants with original rootstock roots and plants with rootstock root excision and regeneration, as both are currently provided by commercial nurseries. Plants were transplanted into the fumigated field on 20 Mar. (early) and 6 Apr. (late), respectively. Destructive plant sampling before the first harvest showed that all the grafted plants had more female flowers compared with the non-grafted plants, while similar numbers of female flowers were found between the two types of grafted plants. However, the full-season yield components including marketable and total fruit numbers and yields as well as the average fruit weight did not differ significantly between grafted and non-grafted plants. In contrast, early planting led to significantly higher marketable and total fruit yields primarily due to increased averaged fruit weight, in comparison with late planting. No significant interactions between planting date and grafting were observed. With respect to each harvest, early planting significantly improved marketable fruit yield compared with late planting at the first harvest. Although statistical significance was not observed (*P* = 0.068), grafted plants especially those with ‘Super Shintosa’ rootstock tended to have higher marketable fruit yield than non-grafted plants at the first harvest. At the second harvest, non-grafted plants showed the highest marketable fruit yield, while no significant effect of planting date was observed. Average fruit weight was significantly higher at early planting than late planting for both harvests, while it did not differ significantly between grafted and non-grafted plants. Planting date and grafting did not show any significant impacts on fruit yield from the third harvest. Fruit quality assessment showed similar levels of soluble solids content, pH, and titratable acidity between grafted and non-grafted plants regardless of root excision and regeneration. However, early planting resulted in a significant increase in fruit pH with lower titratable acidity compared to late planting.

*Specified Source(s) of Funding:* Florida Specialty Crop Block Grant Program

**Soil Fertility Drives Yield Gains and Losses of Grafted Heirloom Tomatoes in Nebraska** *(Poster Board #025)*

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Grafting heirloom tomato (*Solanum lycopersicum*) cultivars onto hybrid tomato rootstocks can increase yield, mineral nutrition, drought tolerance and disease resistance. In 2017, the determinate heirloom tomato ‘Nebraska Wedding’ was grafted onto two rootstocks, ‘Estamino’ and ‘Maxifort’. Non-grafted and self-grafted ‘Nebraska Wedding’ plants were controls. Plants were grown in a high fertility soil in Lincoln, NE (residual NO₃-N = 10.7 ppm; P = 90 ppm, and K = 410 ppm), and in a low fertility soil near Mead, NE (residual NO₃-N = 3.2 ppm; P = 5.5 ppm, and K = 296 ppm). Plants received no nitrogen fertilizer (control) or 168 kg·ha⁻¹ N from yardwaste compost, calcium nitrate [Ca(NO₃)₂] fertilization, or both (84 kg·ha⁻¹ N from each source). In the high fertility soil, grafting tomatoes with ‘Estamino’ or ‘Maxifort’ reduced yield by 41% and 48% relative to non-grafted plants. Fertilizer and compost did not affect tomato yield in the high fertility soil, but did increase leaf nutrition. In the low fertility soil, tomatoes grafted to ‘Estamino’ had 20% greater yield than non-grafted plants. Fertilizing with Ca(NO₃)₂ alone and in combination with compost also increased tomato yield in the low fertility soil, and plants grafted to ‘Maxifort’ and fertilized with Ca(NO₃)₂ and compost had greater leaf tissue nitrogen, phosphorus, and potassium. Results suggest that grafting and integrated nitrogen management can increase tomato yield and leaf nutrition, especially in a low fertility soil. However, grafted tomatoes grown in a high fertility soil may have excessive vigor and reduced harvest index.

*Specified Source(s) of Funding:* USDA AMS Specialty Crop Block Grant Program

An asterisk (*) following a name indicates the presenting author.
Reversal of High Temperature Induced Flowering Delay in Poinsettia with Photoperiod

(Poster Board #098)

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Plants of ‘Prestige Red’ poinsettia (Euphorbia pulcherrima Willd. Ex Klotzsch) were grown in greenhouses in Overton, TX, to determine if photoperiod could be used to hasten flowering under high temperature conditions. Flowering of this cultivar is known to be delayed by 4 weeks of high temperatures under natural photoperiod during floral initiation. Plants were potted in early September and pinched to 5 nodes two weeks later for natural season flowering. Plants were exposed to either 0, 2, or 4 weeks of a high temperature treatment consisting of a daily average temperature of 27 °C starting at the time of the pinch. During the high temperature treatment, half the plants were exposed to a natural photoperiod and the other half were exposed to a 9-hour short day with a 15-hour night using black cloth. For the rest of the forcing period, an average daily temperature of 22 °C was maintained. Dates of first bract color, visible bud, and anthesis were recorded for each plant. There was no difference in number of days to anthesis from start of treatment for plants with 2 weeks of high temperature at either photoperiod compared to those with 0 weeks of high temperature. However, short days hastened anthesis for plants with 4 weeks of high temperature when compared to plants with 0 or 2 weeks of high temperature under either photoperiod. These relationships held for days to visible bud from treatment as well. When considering days to first bract color from treatment, 4 weeks of high temperature delayed color development on plants under natural days. But, this effect was reversed by short day exposure during the high temperature treatment, though no further hastening by short days was seen. This indicates that short days can be used to reverse the delaying effects of high temperature on flowering.

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Development of a High Performance Liquid Chromatography (HPLC) Protocol for Identification and Quantification of Anthocyanins in Poinsettia Bracts

(Poster Board #099)

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Poinsettia (Euphorbia pulcherrima) is the most popular holiday potted plant, with eye-catching bracts colored by anthocyanin pigments that attract consumers to buy the plants every holiday season. Poinsettia breeders are constantly challenged to create new and improved cultivars for the industry, and anthocyanin profiles can aid in cultivar development. Identification and measurement of anthocyanins in poinsettia cultivars has not been conducted since the 1980s, thus pigment profiles of modern poinsettia cultivars are lacking. A standard method to identify and quantify the anthocyanins in poinsettia bracts using High Performance Liquid Chromatography (HPLC) does not exist. Methods for extracting and analyzing anthocyanins in pitanga fruit were adapted for poinsettia bracts. Methanol extraction was followed by pre-purifications to remove lipophilic compounds and separation from other flavonoids using a C18 solid matrix. Finally, acid hydrolysis removed sugars from the compound before analysis using HPLC. The adapted protocol results in accurate identification and quantification of the anthocyanins in poinsettia bracts and also in optimal HPLC chromatograms of high resolution with sharp symmetrical shape on a flat baseline. An updated, efficient HPLC protocol to identify and quantify the anthocyanins in poinsettias will be used to characterize the anthocyanin profiles of modern cultivars and create a database of the pigments. It will also be used in future studies to quantify the effects of temperature and light on anthocyanin content in poinsettia bracts. Ultimately, this information will be beneficial to poinsettia breeders when characterizing new germplasm and new hybrids. We thank the Monsanto Graduate Fellowship for funding.

**Specified Source(s) of Funding:** Monsanto Graduate Fellowship

**Effect of Light Qualities Modified by Dye-sensitized Solar Cells and Light-emitting Diodes on Plant Shape, Growth, and Flowering of Petunia** (*Poster Board #100*)

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Dye-sensitized solar cell (DSC) can be used as a greenhouse glazing material because it is translucent with various colors and produces electricity. However, light quality under DSC is different to that of sunlight and its transmittance of visible light is low. Therefore, we compared the growth and physiological responses of petunia (*Petunia xhybrida*), a very sensitive plant to light condition, under transparent glass and red-colored DSC. Petunia ‘Madness Red’ were grown in transparent (T, the control), shading (S), and DSC (D) chambers maintained at 23 ± 2°C, and DSC chambers supplemented lighted with high-emitting diodes (LEDS) (D+L) of blue (B), green (G), white (W), B+G, and R+B+W colors for 16 hours from 06:00 to 22:00 with 60 µmol·m⁻²·s⁻¹ PPFD. S and D increased plant height compared with T, and D+L(W) LEDs decreased plant height to the level of T. Plant height under D+L(G) was higher than D, whereas that of D+L(R+B+W) was lower than T. Number of leaves and shoot weights decreased under S and D compared with T, and supplemental lighting with all the LEDs significantly increased number of leaves and shoot weight to the lower level under T. Chlorophyll content decreased under S and D and was recovered to the level of T by LED supplemental lighting except for G. Whereas root weight under LEDs was higher than that under T. So T/R ratios under D+L(B) and D+L(B+G) were lower than that under T. In addition, DSC delayed flowering compared with T, whereas LED lighting except for R+G+B enhanced flowering compared with T. The flower color under T, D+L(B) and D+L(B+G) was darker and redder than that under S and D. In conclusion, petunia grown under DSC had stretched stems and less leaves, lighter biomass, later flowering date and lighter flower color compared with T. Supplemental lighting by LEDs with blue wavelength under DSC improved growth, flowering and plant quality such as plant form and flower color.

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**Assessing the Application of Supplemental Lighting for Short-day Crops Using Light-emitting Diodes** (*Poster Board #101*)

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Reducing time to flower and improving overall crop quality by providing supplemental lighting (SL) for bedding and potted plants that are either day-neutral or facultative long-day is a proven strategy. However, there is less research on the benefit of SL on short-day plants with respect to plant morphology, growth, and time to flower delivered during both the long-day and short-day phases. Through a coordinated grower trial, Winter–Spring 2017–18, we investigated the effect of SL on the short-day plant *Kalanchoe blossfeldiana* with respect to growth and development. Initially, during the long day grow phase SL was delivered at 85 µmol·m⁻²·s⁻¹, provided when necessary to achieve an approximate daily light integral (DLI) of at least 10 mol·m⁻²·d⁻¹ during an 18-h photoperiod. Depending on ambient light intensity, SL typically was utilized for an average of 14 h/day. Supplemental lighting from both light-emitting diodes (LEDS) and high-pressure sodium (HPS) lamps were evaluated in separate sections of the greenhouse. The composition of wavelengths from the LEDs was approximately 19% blue, 4% green, and 77% white. At transfer from long days to short days, compactness, an important measure of plant quality, was greater among plants grown under LED SL than those grown.
Effects of Pine Bark Substrate Age on Paclobutrazol Efficacy and Growth Control in Marigold (Poster Board #102)

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Previous research has shown that pine bark as a horticultural substrate can reduce the efficacy of drench applied plant growth regulators (PGR). There is however no understanding or evaluation of the effect of pine bark age on substrate interaction with PGRs. Physical and chemical characteristics of pine bark have been shown to change significantly over time during the aging or composting process. Therefore, the efficacy of PGRs in substrates containing pine bark may be affected by the age of the pine bark used. To address this question, Paclobutrazol drench applications of 0, 1, 2, and 4 mg were applied to ‘Antigua Yellow’ marigold (Tagetes erecta) grown in 1L plastic containers filled with a 2:2:1 (v:v:v) peat: pine bark: perlite substrate. The pine bark of various ages was obtained from a commercial bark supplier. Bark substrates obtained and used in this study were 0, 3, 6, 9, and 12 months old. After six weeks, plant height, growth index, and dry weights were recorded. There was an interaction between PGR rate and bark age for marigold growth indices but not for plant height and dry weight. Marigold height increased when grown in substrates containing 6-month aged bark and was similar in 9- and 12-month aged bark as well. Plant dry weights increased as pine bark age increased from 0 to 12 months. These results indicate that pine bark age does affect marigold growth but the interaction between pine bark age and paclobutrazol efficacy was inconclusive.

Comparison of Calcium and Silicon Sources for Botrytis Efficacy and Phytotoxicity (Poster Board #103)

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Spray applications of calcium applied to petunia plants improve the resistance of petunia (Petunia hybrida) flower petals to Botrytis cinerea infection. The objective of this experiment was to evaluate the effect of various calcium sources for Botrytis control and their potential phytotoxicity. Products examined included, calcium chloride, calcium silicate, potassium silicate, calcium EDTA, calcium nitrate, and calcium metalosate. Three application rates were chosen for each calcium source. A 1–5 scale was used to evaluate spray damage on petunia flowers (1 = no damage; 5 = 75-100% damage). Flower bleaching (pigment loss) was evaluated on a 1–3 scale (1 = no bleaching; 3 = severe pigment loss). Flowers were treated at different stages of development (buds and 1, 3, 5, and 7 d old open flowers prior to treatment). After the single spray application of the calcium treatments, flowers were then rated 1, 3, 5, and 7 d after the spray. Three to 5 day old flowers were the most susceptible to spray damage, whereas buds were the least susceptible. Calcium chloride and calcium nitrate had the least amount of spray damage and flower bleaching, while potassium silicate and calcium EDTA had the most. Once all the opened flowers had died, the plants returned to a normal appearance except for the higher rates of calcium EDTA which continued to produce damaged flowers for several days after the treatment. Botrytis efficacy trials were conducted to determine which nutrient sources provided the most disease control.

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Survey of North American and European Wood Substrate Products and Manufacturing Processes (Poster Board #104)

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With the continued interest in alternative horticultural substrates, specifically wood-based substrates, there remains a void of published information describing the differences in many of the commercially available materials on the market today. The results from many grower trials and independent company R&D trial results are trickling information out to the industry but a thorough overview of products and product differences is needed. A survey of wood substrate materials in North America and Europe was conducted from 2015–18 during which time as many of the available wood product’s as possible were acquired for the purpose of laboratory and greenhouse testing and comparison trials. In addition to product acquisition, information was gathered (when possible) on the type of machinery and processing techniques that were used to create each specific wood component. Of the 30 plus materials collected, observed, evaluated, or tested there were three different machine types identified that produced most all of the wood products: 1) single
or twin screw extruders/retruders; 2) twin disc refiners; or 3) hammer mills. Each machine/processing type creates unique wood particles and unique substrate blends/mixes. The different processing types have different effects on the wood chemical properties and phytotoxic potential of the end product. The three processing methods also have differing abilities to be modified or manipulated to create variations among or within their products (fiber thickness, fiber length, wood particle shape, wood particle size, etc.). Upon evaluation of numerous materials manufactured from each of the three machine types, no one product (or process) is superior to others and each one has pros and cons relative to expense, variability in product offerings, annual maintenance costs, product consistency, properties of the end product material, etc. As commercialization of wood substrates continues, more scientific information and product trial testimonies from growers who choose to use them will be available.

**Local Food Systems (Poster)**

**Consumer Acceptability of Locally and Commercially Grown Spinach.** *(Poster Board #225)*

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The consumer demand for locally grown fresh produce is continuously increasing in the United States. The high tunnel systems have been successfully utilized by small acreage growers for local production. Consumers are typically assessing appearance, freshness, flavor and aroma when purchasing produce. A common perception is that locally grown produce tastes better than non-local. However, there is not much information about the effect of locality on the consumer acceptability and sensory characteristics of spinach. The objective of this study was to identify consumer acceptability and the sensory characteristics of locally grown spinach in open field or in high tunnel and non-local commercially grown spinach. The consumer study (n = 205) was conducted at Kansas State University, Olathe campus, and the descriptive sensory analysis was conducted by a highly trained descriptive analysis panel in the Center for Sensory Analysis and Consumer Behavior at Kansas State University, Manhattan campus, in spring 2017. Spinach, *Spinacia oleracea* cv. “Corvair” was grown in open field and in high tunnel at Kansas State University Olathe Horticulture Research and Extension Center (OHREC) in spring 2017 and the commercially grown spinach was purchased at a local retail store. Consumer questionnaires evaluated the preference of the three types of spinach on the basis of appearance, overall liking, flavor and texture using a 9-point hedonic scale. The consumer test showed that high tunnel spinach scored significantly higher in overall liking (p<0.0001), flavor liking (p<0.0001) and texture liking (p<0.05) when compared to open field and store purchased spinach. There was no significant difference in appearance liking between the three types of spinach. Descriptive analysis showed that locally grown spinach had higher intensity of attributes that indicate high quality, such as green color and green/spinach flavors. Our results indicate that locally grown spinach is preferred from the consumers for its high organoleptic quality.

**Planting Density Effects on Romaine Lettuce Grown in Sub-irrigated Containers** *(Poster Board #226)*

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Homeowners interested in the source of their food are continuing to drive the increased interest in home vegetable gardens. This is especially true in urban areas where small yards are the norm. Self-irrigated containers offer a successful gardening system for gardeners with limited space such as small yards, porches, or even balconies to grow vegetables. The goal of this project was to grow at three planting densities green and red romaine lettuce (*Lactuca sativa* var. *longifolia*) transplants commonly found by home gardeners at garden centers. The commercially available sub-irrigated EarthBox was used. Following the home owner instructions each EarthBox received pre-plant fertilizer (1 cup 10–10–10) and dolomitic lime (2 cups). Transplants grown in Jumbo 606 packs were planted on 30 Jan. 2017, into peat-based container mix (Sunshine #8). Planting density treatments were 2, 4, or 8 transplants per sub-irrigated container. All plants were harvested on 21 Mar. 2017. Data collected included weight of individual romaine lettuce heads and total weight per sub-irrigated container. Overall, the green romaine head weights were greater than the red. The total head weights for the green romaine produced greater weights per sub-irrigated container regardless of planting density. Planting density total head weights

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An asterisk (*) following a name indicates the presenting author.
regardless of lettuce type were similar for the 4- and 8-transplant treatments and greater compared to the 2-transplant treatment. When comparing the green and red romaine lettuce there was no difference in the two head treatment, but individual green heads were greater than the red in the four and eight head density treatments. This information is valuable for the home gardener with limited growing to determine how much romaine lettuce to grow to meet family needs.

**Orchid (Poster)**

*Strategies for Developing Cold Tolerant Epiphytic Orchids (Poster Board #106)*

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Orchids are currently one of the most popular floriculture crop worldwide, and rank top in production in the United States. Consumers nowadays can purchase exotic orchids from various venues, not limited to traditional orchid nursery, but also from grocery and hardware stores. The present popularity of orchids is partially due to the continuous effort by hybridizers to increase flower size, improve flower shape and color. Despite a rather intense breeding effort, additional characteristics such as cold hardness or tolerance should be considered to make orchids even more popular or approachable to the general public or reduce the heating cost during production. Several species of *Cymbidium, Dendrobium*, and ones belonging to the subtribe Laeliinae show a certain degree of cold hardiness and those species have been casually used in developing hybrids. However, no specific and systematic attempt has been made to impart cold hardiness into commonly available orchids. At Kentucky State University, breeding effort is underway to develop temperature tolerant epiphytic orchids, utilizing some of these cold hardy orchids such as *Cymbidium goeringii, Dendrobium moniliforme, Epidendrum magnoliae, Encyclia tampensis* and *Laelia anceps*. In this presentation, strategies in for developing cold tolerant epiphytic orchids will be discussed.

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**Adaptation and Challenges of Orchid Conservation in South Florida (Poster Board #107)**

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South Florida has an ever changing community and climate; however, with these changes comes a lot of pressure on the natural environment. With climate change, overpopulation, and invasive species our native orchids face the threat of extinction. In the Million Orchid Project at the Fairchild Tropical Botanic Garden, native and non-native orchid species are propagated in the tissue culture lab mostly from the seeds, transferred to the nursery, and eventually back into the South Florida Environment. This research analyzes the way these sprouting orchids begin to adapt into the environment as they are attached onto different tree species, orientations, and heights throughout the Garden. *Encyclia tampensis, Bletia purpurea, Oncidium ensatum*, and *Cyrtopodium punctatum* orchids ranging from natives to non-natives will be placed around the Garden. Different parameters such as root count, root length, number of the leaves, and the soil-plant analyses development non-destructive handheld sensor will be used in order to determine overall plant health to determine the plants adaptation. Once the orchids have begun to adapt to their new environments, the roots will be examined for fungi and it will be determined if the fungi affects development of the plant and seedlings. The species of beneficial fungi will also be determined in order to be able to use that strain to help the development of those orchid species in the lab for the future.

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**Growth Response of Doritaenopsis Queen Beer ‘Mantefon’ By Changes of Light Intensity and Nitrogen Supply under CO2 Enrichment (Poster Board #108)**

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Light intensity and nitrogen is required to increase leaf growth under CO2 enriched conditions. The first, second, third, fourth, and fifth emerged leaf growth was investigated under 800 µmol mol−1 CO2 during 40 weeks with two light intensity (150 and 300 µmol m−2s−1) and four nitrogen concentrations [N1 (0.013 kg L−1), N2 (0.033 kg L−1), N3 (0.053 kg L−1), and N4 (0.073 kg L−1)]. Phosphate (0.013 kg L−1) and potassium (0.013 kg L−1) was supplied at each treatment. At N2, total number of leaves increased in the plants under 300 µmol m−2 s−1 than the plants under 150 µmol m−2 s−1. Survival rates were 100, 93, and 60% in the plants with N1, N2, and N3, respectively, grown under 150 µmol m−2 s−1. Survival rate was 100, 100, and 80% in the plants with N1, N2, and N3, respectively, grown under 300 µmol m−2 s−1. At N1, the length and width of the second, third, fourth, and five emerged leaves was not significant between 150 and 300 µmol m−2 s−1. Leaf span decreased by increasing nitrogen supply, regardless of light intensity. Plants were not survived at N4 in 150 and 300 µmol m−2 s−1. Overall, Plants survival could improve under 300 µmol m−2 s−1 compared to 150 µmol m−2 s−1 and nutrient supply at N2 is economic benefit for farmers, considering leaf span.

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**Tissue Culture Laboratory Transformed Orchid Businesses on a Tropical Island of Guam** (Poster Board #109)

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Orchids represent 600–800 genera with close to 35,000 species. Tropical Guam has the perfect climate to grow them. Flowers are highly desired by residents and the 1.5 million tourists visiting the island every year. Over the last several decades, most of orchids that were being grown on Guam were imported from Hawaii and Southeast Asia. Unfortunately, detrimental viral diseases entered Guam with the imported plants infecting about 70% of existing orchid plants and causing their steady decline. Starting in 2012, the Guam Department of Agriculture initiated a tissue culture program aimed to eliminate diseased plants, significantly reduce Asian imports and to develop a sustainable production of disease-free orchids on island. Within three years, the Tissue Culture Laboratory developed orchid production to such a level that the importation of diseased plants was largely reduced. Local nurseries and the general public were given the opportunity to replace their diseased plants with healthy ones. In addition, they were able to purchase inexpensive, well-developed seedlings of disease-free orchids in large quantities. Harmful in-house propagation of diseased plants virtually ceased in nurseries and was greatly reduced in amateur growers. Additionally, several Guam residents (employed by the project) developed the skills of tissue culture propagation that gave them a competitive edge in this emerging job market. As a result of the program, hotels, restaurants, and Guam’s residents had a way to acquire healthy less expensive orchids so that millions of Guam visitors could experience more of the beauty the island has to offer.

**Plasticulture (Poster)**

**Soil Sampling to Assess Biodegradable Plastic Mulch Fragments in Soil** (Poster Board #184)

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Biodegradable plastic mulch is designed to be tilled into the soil after use, eliminating environmental and economic issues associated with plastic mulch removal and disposal. There is a need for a soil sampling protocol that can accurately assess the amount of biodegradable mulch remaining in a field post soil-incorporation. An experiment was carried out at Mount Vernon, WA to develop such a protocol. Three blocks each of five beds measuring 1 m wide × 10 m long, spaced 2 m on center, were covered with a biodegradable mulch (Organix, Organix Solutions, Maple Grove, MN). Sixty-one days later, beds were disked, first in the direction parallel to the beds and then in the direction diagonal to the beds, as is the common grower practice in this region. Blocks were separated from each other by 8 m so the tractor-tiller could turn without entering an adjacent block. In each block, 24 soil samples were collected 1-3 day after discing: 12 were from the center of the three center mulched beds (four samples per bed) and 12 were from the center of the three center alleys (four samples per alley). For each sample, soil was collected from a 1 m² area to a depth of 15 cm using a shovel. The amount of soil sampled was then reduced using the quartering method: the soil was placed on a piece of plywood, mixed thoroughly, divided into quarters by two lines intersecting at right angles at the center of the pile, and two diagonally opposite quarters were discarded. This procedure was carried out a total of three times so that the final sample size (19 L) was 1/8th of the original sample size. Mulch fragments were then recovered from each soil sample, and the mulch area was measured. There was no difference in the amount of mulch recovered from the beds and the alleys (91 to 110%), indicating that mulch fragments were distributed evenly throughout the field. The 95% confidence interval for the recovery rate was 100 ± 11%, indicating this method was reliable and repeatable. Thus, soil sampling using the quartering method can be used to assess the amount of mulch remaining in the field after tillage incorporation when the field is tilled parallel to the bed and then diagonally, and the location of the soil sample relative to the bed center will not affect the amount of mulch recovered.

**Rowcover Reduces Water Requirements and Increases Water Use Efficiency in Spring Production of Brussels Sprouts** (Poster Board #185)

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Determining irrigation requirements for Brussels sprout production under rowcover is essential to maximize yield and improve water use efficiency (WUE). The response of spring-planted Brussels sprouts to two plastic mulches (black and white) in combination with spun bonded rowcover and no rowcover was investigated at the Eastern Shore Agricultural Research and Extension Center of Virginia Tech on a Bojac sandy loam soil. The objective of this study was to determine the difference in water requirement and WUE under rowcovers compared to open field conditions. Plants were irrigated based on soil moisture and an irrigation event was initiated at 50% deficit of the plant available water. The amount of water applied (irrigation time) was estimated to bring soil moisture in the root zone to field capacity. In addition, temperature, humidity, wind speed, and solar radiation were measured in the canopy to estimate and compare evapotranspiration under rowcovers with the open field. Rowcovers increased air temperature in the growing season, but
reduced solar radiation and wind, so evapotranspiration was less under rowcovers in comparison to the open field. Lower evapotranspiration was associated with less irrigation under the rowcovers compared to the open field. Rowcovers increased plant growth, stem length, number of sprouts, and total yield. In conclusion, rowcovers increased Brussels sprout production and WUE, which may justify their use to improve the sustainability of vegetable production in water limited areas.

Specified Source(s) of Funding: Southern SARE

Promoting Productivity and Efficiencies in Summer Planted Tissue Culture Floricane Raspberry Using Biodegradable Plastic Mulches (Poster Board #186)

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Floricane red raspberry (Rubus ideaeus) in northwest Washington is typically grown in raised beds and weeds are managed through a combination of herbicide applications and hand weeding. Late summer plantings of tissue culture (TC) raspberry are increasing in Washington because growers find improved establishment relative to traditional spring planting. However, TC transplants can be difficult to establish relative to traditional dormant roots and cane planting materials. Ongoing research has shown polyethylene (PE) and biodegradable plastic mulches (BDMs) improve weed management and promote vegetative plant growth in spring planted TC raspberry transplants. Yet, impacts of plastic mulches in late summer plantings are unknown. Plastic mulches applied in late summer need to overwinter with minimal damage, should provide weed suppression until the following spring, and should also not increase populations of root lesion nematode (Pratylenchus penetrans; RLN), a plant-parasitic nematode with a wide host range. The overall objective of this study is to develop knowledge and practical strategies to improve establishment of late summer planted TC raspberry transplants through application of PE mulch and BDMs prior to planting. Six treatments, including four BDMs, a PE mulch, and a bare ground (BG) control are being evaluated in a commercial “WakeHaven” raspberry field planted Aug. 2017, in northwest Washington. Crop growth, weed suppression, mulch performance [as percent soil exposure (PSE)], soil temperature and moisture, and RLN populations were measured in 2017. Average primocane height was 5 cm greater in all mulched treatments relative to BG control 30 days after planting, but this numeric difference was not statistically significant. There were no weeds in any of the mulched treatments, whereas BG control plots were weedy (51 weeds/m²) both in Sep. and Oct. 2017. Despite lack of statistical differences, average PSE was 1.4% and 2 to 15% by Dec. 2017, in the PE and BDMs treatments, respectively. Mulch damage was mainly caused by farm equipment and resultant punctures were enlarged by wind. RLN populations in soil in Oct. 2017, were not different between treatments. Plant growth, RLN population dynamics, and yield data will be collected in 2018 and 2019.

Specified Source(s) of Funding: Washington Red Raspberry Commission and Washington Commission on Pesticide Registration

Commercial Biostimulants Increase Biodegradation of Polylactic Acid Based Agricultural Mulches Containing Alfalfa or Soy Particles (Poster Board #187)

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Polylactic acid (PLA) based agricultural mulches provide several benefits including environmental sustainability, durability, weed control, and soil moisture conservation. Despite these potential benefits, large-scale adoption of PLA mulches in organic and conventional agricultural systems has been hampered by unpredictable biodegradation and persistence in soil. A 16-week microcosm study was implemented to assess the effects of four commercially available biostimulants including Biocat 1000, Extract PBA, Custom GP, and Environoc 501, a compost extract, and distilled water, urea, and sucrose controls on biodegradation and microbial respiration of bio-based agricultural mulches in native soil. Mulches included PLA biofabric, two novel composite PLA biofabrics with embedded alfalfa (PLA-A) and soy (PLA-S) particles, paper mulch (PA), and bioplastic film (BF). After 16 weeks, the PLA-A and PLA-S mulches lost 195% more mass than the PLA mulch. Cumulative microbial respiration in the PLA-A and PLA-S mulch microcosms was 245% and 239% greater than respiration in PLA mulch microcosms. Cumulative and weekly microbial respiration measurements were similar for PLA and BF treatments. The effects of biostimulants on biodegradation and microbial respiration were inconsistent across mulch treatments. However, Extract PBA increased PLA-A biodegradation by 64% and cumulative microbial respiration by 43% compared to water. These results are consistent with previous research demonstrating correlation between mulch biodegradation and microbial respiration. Overall, results suggest that composite PLA-based biofabrics
Assessing Microbial Communities of Compost Extracts and Their Effects on Lettuce Growth after Residue Incorporation in Soil

*(Poster Board #188)*

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Biodegradable and organic mulches are potentially sustainable alternatives to polyethylene film in vegetable production, but annual soil incorporation of biobased mulch may interfere with subsequent crop growth. However, it may be possible to speed degradation (and minimize nitrogen immobilization) by inoculating residues with compost extracts. Little is known about the microbial composition of compost extracts from different feedstocks and how these extracts influence plant growth following mulch incorporation. We completed a series of biological tests to characterize 10 compost extracts, including nematode extraction, protozoa most probable number assay, fatty acid methyl ester (FAME) profiles and microscopic counts for total bacterial and fungal indices, a colorimetric assay, and a lettuce seed phytotoxicity bioassay. Based on test results, three non-phytotoxic compost extracts (from vermicompost, yardwaste, and chicken manure feedstocks) were selected to explore effects on lettuce growth in residue-rich soils in a greenhouse. Extracts contained a diverse range of bacterial (0–12 nmol FAME/mL), fungal (0.67–2.15 nmol FAME/mL), protozoa (4660–466,780/mL), and nematode (0–22/mL) concentrations. Soil-incorporated mulch residues included alfalfa (equivalent to 11.2 Mg/ha), straw (4.5 Mg/ha), and wood particle-loaded polylactic acid (PLA) mulch (3.8 Mg/ha), and all residues were inoculated with extracts at a nitrogen-adjusted rate of 3.4 kg N/ha (2000–4800 L/ha). The interacting effects of residue and extract influenced lettuce growth. High carbon residues, including PLA mulch, reduced growth and extracts had no effect in these treatments; however, inoculation of alfalfa residue with yardwaste and chicken manure compost extracts increased lettuce growth 60% to 72%, respectively. The growth-promoting extracts contained less microbial biomass and microfauna than the vermicompost extract, which performed comparably to the control. Results suggest that certain compost extracts can enhance lettuce seedling growth when applied to high nitrogen residues before soil incorporation.

**Specified Source(s) of Funding:** USDA NIFA ORG award # 2016-51106-25711

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**Nitrogen Requirement and Use Efficiency Increased for Optimal Basil Production under Rowcover Compared to Open Field**

*(Poster Board #189)*

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Nitrogen (N) use efficiency (NUE) is important in a sustainable vegetable production system and has a significant impact on the system’s nutrient management. Rowcover enhances vegetative growth but N requirement may differ from open field for optimal growth and yield, and N use efficiency. The study was conducted at the Eastern Shore Agricultural Research and Extension Center (AREC), Painter, Virginia Tech, VA, (longitude −75.82114 and latitude 37.58466). The objective was to determine differences in N requirement and use efficiency in basil under rowcover compared to open field. The experimental design was a split plot with four replications. The main effect was N fertilizer rate (0, 37, 74, 111, 148, and 185 Kg·ha⁻¹) and the secondary effect (subplots) was low tunnel covered with spun-bonded row cover (Rewitt, 1 oz/yard², River Birch Mall, 905 S Kings highway, Sikeston, MO 63801) and no cover. Total fresh weight, and biomass increased with rowcover by 61.0 %, and 73.5% respectively. Fresh weight per plant increased exponentially (R² = 0.99) with N fertilization from 832 to 1520 g under rowcover, and linearly (R² = 0.87) from 555 to 844 g without rowcover. Although NUE increased with rowcover overall and at each fertilization rate, it decreased as the N fertilization rate increased. Height and stem diameter were not different among the fertilization rates. In conclusion, the increase in basil growth and yield due to N fertilization, and the NUE were greater under rowcover than open field.

**Specified Source(s) of Funding:** Southern SARE

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**Tomato Grafting: Developing High Tunnel Grower Recommendations and Enhancing Our Understanding of the “Rhizobiome”**

*(Poster Board #190)*

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Tomato grafting is being rapidly adopted by high tunnel growers, and yield due to N fertilization, and the NUE were greater under rowcover than open field. The experimental design was a split plot with four replications. The main effect was N fertilizer rate (0, 37, 74, 111, 148, and 185 Kg·ha⁻¹) and the secondary effect (subplots) was low tunnel covered with spun-bonded row cover (Rewitt, 1 oz/yard², River Birch Mall, 905 S Kings highway, Sikeston, MO 63801) and no cover. Total fresh weight, and biomass increased with rowcover by 61.0 %, and 73.5% respectively. Fresh weight per plant increased exponentially (R² = 0.99) with N fertilization from 832 to 1520 g under rowcover, and linearly (R² = 0.87) from 555 to 844 g without rowcover. Although NUE increased with rowcover overall and at each fertilization rate, it decreased as the N fertilization rate increased. Height and stem diameter were not different among the fertilization rates. In conclusion, the increase in basil growth and yield due to N fertilization, and the NUE were greater under rowcover than open field.

**Specified Source(s) of Funding:** Southern SARE
produced in high tunnels. The trials were conducted from 2013–16 on three commercial farms (two organic) and at the Olathe Horticulture Center. ‘Arnold’, ‘Maxifort’, and ‘Colosus’ rootstocks provided 20% to 73% increases in fruit yield in our trials (P < 0.05). Conversely, ‘RST-04-106’ and ‘RT 1028’ rootstocks provided no benefit under little disease pressure and across four locations. We profiled the root rhizobiome by sequencing bacterial 16s ribosomal rRNA and fungal ITS regions from the rhizosphere and within plant roots from the trial sites. The majority of observed microbial taxa were shared; however, a small percentage (less than 3%, P < 0.05) were associated with genotype. Interestingly, a more diverse community was observed on ‘Maxifort’ rootstock. The results of this project identify certain rootstocks that lead to higher productivity for organic and conventional high tunnel tomato growers and show that the rhizobiome of grafted plants is somewhat different than nongrafted tomato. This presentation will highlight the activities and impacts of a North Central Region SARE project (LNC13-355) and was also supported by the Ceres Trust and USDA SCRI.

Specified Source(s) of Funding: NCR-SARE, Ceres Trust

The Impact of Light on Yield and Quality of Tomato and Lettuce Grown in High Tunnels (Poster Board #191)

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The utilization of high tunnels is growing across the United States and is particularly important for facilitating an expanding local food production system. The benefits of season extension and/or environmental protection have been shown to improve crop productivity characteristics within a number of fruiting vegetables and leafy crops. However, there are sporadic reports of inconsistent and/or negative impacts on nutritional quality when compared to the open-field. In particular, ultraviolet (UV) light can affect antioxidant capacity and other phytochemical production. The goal of this project was to evaluate the impact of different polyethylene films (standard poly, diffusion poly, clear poly (no UV blocking), UVA + UVB blocking (< 380–400 nm)), as well as 55% shade cloth and a simulated movable tunnel on light, temperature, crop yield, shelf life, and nutritional quality of tomato and lettuce. Trials were conducted in 2017 (summer tomatoes, fall lettuce) at the Kansas State University Olathe Horticulture Center in four, 12’ × 130’, seven-foot tall high tunnels. The trials were arranged in a RCBD and each tunnel served as a replication. Average soil and canopy temperatures were affected by high tunnel covering and the average soil temperature was higher in the plots where the clear poly was used (P < 0.001). The plants grown with 55% shade cloth (applied 6 WAP) had dramatically lower marketable tomato fruit yield than all the others with the exception of the UVA + UVB blocking poly (P < 0.05). Similar results were seen with lettuce (P < 0.001) and visual observations show varying levels of red color in ‘New Red Fire’ whereas green lettuce, ‘Two Star’ was generally unaffected. There were no significant differences in ascorbic acid (vitamin C) amongst the different treatments for tomato. High tunnel production systems offer a unique opportunity to manipulate light with various coverings such as different polyethylene films and/or shade cloth that typically cannot be accomplished in the open-field. In order to address production limitations, a further understanding of the impact of light on vegetable crops will be instrumental to furthering local and regional production of fresh-market vegetables.

Specified Source(s) of Funding: USDA NIFA AFRI

Produce Quality, Safety, and Health Properties (Poster)

On-Farm Readiness Review: A Collaboration between the Food and Drug Administration, National Association of State Departments of Agriculture, United States Department of Agriculture, State Extension Services, and State Regulators (Poster Board #227)

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The Produce Safety Rule (PSR) was published by the U.S. Food and Drug Administration (FDA) in the Federal Register in Nov.
2015 as one of seven major new regulations under the Food Safety Modernization Act (FSMA). The PSR covers activities related to the growing, harvesting, packing, and holding of fresh-market produce, with a few specific exemptions. Growers need to go through an FDA approved food safety training prior to being inspected. Currently the Produce Safety Alliance training is the only recognized training. After attending the course and developing awareness of the key PSR requirements, many growers still have questions about different ways that the PSR requirements might be met in their operations. To bridge this critical gap, the National Association of State Departments of Agriculture (NASDA), in partnership with FDA, state departments of agriculture, and extension from Rutgers University, Michigan State University, North Carolina State University and the University of Florida, received funding to develop and deliver an “On-Farm Readiness Review” (OFRR) tool. The OFRR toolkit contains several parts, including an exemption questionnaire to determine if any or all parts of the operation could be excluded from the PSR, a PSR decision tree to determine the sections of the tool that pertain to the operation, FSMA factsheets, and the OFRR resource document. The OFRR resource document consists of 12 sections that refer to each requirement of the PSR. Within each section, there is information on the regulatory requirement for each, examples of possible activities that may lead to compliance with each regulatory requirement, and ways that someone who comes onto your operation may evaluate compliance with each requirement (what they’re looking for) including if a record is required. Every grower participating will receive a copy of the full OFRR tool at the time of the visit. To prepare for On-Farm Readiness Reviews to be conducted in each state training workshops are being conducted nationwide. These On-Farm Readiness Review trainings began in Jan. 2018 to train the FDA, the State regulators, and Extension personnel on how to conduct an On-Farm Readiness Review. The trainings are led by the On-Farm Readiness Review Extension Development team. Data is being collected to evaluate the On-Farm Readiness Review training workshops and actual On-Farm Readiness Reviews.

**Evaluating the Presence of Foodborne Pathogens in Aquaponics in Comparison to Hydroponics** *(Poster Board #228)*

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Aquaponics, a growing trend in food production, integrates aquaculture and hydroponics into one system where plants get nutrition from aquaculture wastewater. Bacteria function as biofilter to convert ammonia into nitrite and nitrate plants absorb mineral nutrients from the water, and then purified water is returned to the fish tanks. Aquaponics offer a promising solution for sustainable food production by reducing the usage of water and chemical fertilizers. However, due to the reuse and recycling of waste and waste-derived materials, it is important to appropriately assess and manage potential risks associated with food safety in aquaponics systems. Therefore, the aim of this study was to determine the presence of foodborne pathogens in aquaponics systems. To assess food safety, we collected irrigation water and plant tissues from two different food production systems: aquaponics and hydroponics. Common foodborne illness pathogens (*Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella enteritidis*) of vegetables were analyzed. We collected roots and edible parts of lettuce, basil, and tomato after 30-day production period. Weighing 25 g of plant tissue into 225 mL peptone water buffer, blend or stomach briefly as necessary. A series of inoculum dilutions were prepared and spread onto selective agar plates. Colonies were counted after incubated at 37 °C for 20 hours. Even though there are more bacteria in water samples in aquaponics than in hydroponics, there were no significance differences in the colony-forming units (CFU) of foodborne illness bacteria in plant tissues. In aquaponics and hydroponics, we observed that bacteria are 99.9% in the water, nearly 0.1% inside the roots, and less than 0.1% in the edible part. Because we didn’t change water in production period and there are many nutrition in the water, bacteria can grow in the water. However, foodborne illness bacteria are hard to be transported in plant tissues, so there are less bacteria in roots and edible parts than in the water. We also found that the CFU of bacteria in tomato roots is 34 times to lettuce roots and 9 times to basil roots, because tomato have longer roots, which provide more space to bacteria growth. Key outcomes are expected to identify the food safety issues in aquaponics systems and to enable future research projects to be targeted for commercial production of concern to fill any knowledge gaps.

**Specified Source(s) of Funding:** USDA-AFRI

**Internalization of Salmonella Inoculated on the Surface of Cucumber Fruit** *(Poster Board #229)*

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An increasing number of foodborne illness outbreaks associated with cucumber has been observed in recent years. During the period from 2006–16, a total of 15 cucumber-associated *Salmonella* outbreaks occurred in the United States. An outbreak in 2014, traced back to the Eastern Shore of Maryland, affected at least 275 people and an environmental source for the *Salmonella* contamination was suspected. Contamination of produce can occur at multiple points throughout the food supply chain but a focus on preharvest contamination has increased as a result of knowledge that pathogens have the ability to become internalized within a variety of crops, including tomatoes, spinach and lettuce. Routes of fruit internalization remain largely unexplored, but enteric pathogens have been reported to undergo chemotaxis toward,
and enter, leaf stomata. Stomata provide a micro-environment shielded from sanitizers and a source of photosynthetically-produced nutrients that facilitate survival. Here we investigated the potential for the human enteropathogen *Salmonella enterica* to exhibit surface attachment on and internalization into cucumber fruit. Mini cucumbers purchased from a local store were exposed to light and inoculated in the mid-section with ~10^6 CFU/mL of *Salmonella* serotype Newport or Poona. After incubation periods of either two or 24 hours, half of the cucumbers were dark-treated to close stomata while the other half were used to enumerate attached cells using direct plating on tryptic soy agar. Dark-treated fruit were then surface sterilized with 0.2% sodium hypochlorite to remove surface-associated cells. Inoculated sections were removed with a sterile scalpel, macerated with a pestle in buffered peptone water and enumerated similarly. For each fruit analyzed, at least one of the two inoculated sections yielded recoverable internalized cells for both the 2- and 24-hour time points, with a statistically significant increase in internalized cells after 24 hours (*P* < 0.05) for both serotypes. After a two-hour incubation and a water rinse to remove unattached cells, reductions of approximately 2 and 0.8 log CFU of Newport and Poona cells/fruit, respectively, were observed. Attachment values were significantly different between serotypes (*P* < 0.05). Quantification of bacteria present after a two-hour incubation and surface sterilization yielded approximately 2 log CFU/fruit for both serotypes, indicating *Salmonella* was able to penetrate the cucumber fruit exocarp and escape application of sanitizing treatment. More work is needed to determine route of entry, however the high degree of internalization reveals a significant food safety risk, as internalized pathogens are protected during subsequent transport and storage. 

*Specified Source(s) of Funding:* University of Maryland, Center for Food Safety and Security Systems

**Evaluating the Presence of Foodborne Pathogens in Aquaponics Incomparison to Hydroponics (Poster Board #230)**

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Aquaponics, a growing trend in food production, integrates aquaculture and hydroponics into one system where plants get nutrition from aquaculture wastewater. Bacteria function as biofilter to convert ammonia into nitrite and nitrate, plants absorb ammonia and nitrate, and then water is returned to the fish tanks. Aquaponics offer a promising solution for sustainable food production by reducing the usage of water and chemical fertilizers. However, due to the reuse and recycling of waste and waste-derived materials, it is important to appropriately assess and manage potential risks associated with food safety in aquaponics systems. Therefore, the aim of this study was to determine the presence of foodborne pathogens in aquaponics systems. To assess product safety, we collected irrigation water and plant tissues from two different food production systems: aquaponics and hydroponics. Common foodborne illness pathogens (*Escherichia coli* O157:H7) of vegetables were analyzed. We collected lettuces leaves and roots after 30-day production period. Weighing 25 g of plant tissue into 225 mL peptone water buffer, blend or stomach briefly as necessary. A series of inoculum dilutions were prepared and spread onto selective agar plates. Colonies were counted after incubated at 37 °C for 20 hours. We found there were no differences in the number of colonies in the leaves of lettuce grown in aquaponics and hydroponics; however, the number of colonies was 2.8-fold higher in the roots of lettuce grown in hydroponics than aquaponics. This may be due to the fact that the concentrations of nitrogen and phosphorous in hydroponics systems are nearly 4-fold higher, respectively, than aquaponics, providing more resources for bacterial growth in hydroponics. We are investigating a culture-based survey of *E. coli* O157:H7, *Salmonella* spp., and *Listeria monocytogenes* in basil and tomatoes in addition to lettuce. Key outcomes are expected to identify the food safety issues in aquaponics systems and to enable future research projects to be targeted for commercial production of concern to fill any knowledge gaps.  

*Specified Source(s) of Funding:* USDA-AFRI

**Survival and Growth of Salmonella and Listeria Monocytogenes on Fresh-cut Fruits and Radish under Different Temperature Abuse Conditions (Poster Board #231)**

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Fresh-cut fruits and vegetables are increasingly being recognized as important vehicles for transmission of human pathogens such as *Salmonella enterica*, and *Listeria monocytogenes*. Understanding the population dynamics of these foodborne pathogens on cut fruits and vegetables stored at different temperatures is critical to improve food safety. We evaluated the survival and growth of *S. enterica* and *L. monocytogenes* on different types of fresh-cut melons and other produce which were exposed to different temperature abuse conditions during seven days of storage. Produce items were purchased from a local wholesale market, including fresh-cut cantaloupe, honeydew, watermelon, pineapple, and radish, cut to cuboid pieces of approximately 8 cm3 and placed into 4 oz portion cups for storage at 4 °C until...
inoculated with a cocktail of three *S. enterica* (SE) serovars and a *L. monocytogenes* (LM) cocktail consisting of three serotypes of *L. monocytogenes* and stored under different temperatures (4, 8, 12, and 35 °C). The results indicated that, under chronic temperature abuse conditions of 8 and 12 °C, all cut melon samples supported significant growth of the inoculated foodborne pathogens, with *S. enterica* populations reaching up to 5.28 log CFU/g and *L. monocytogenes* up to 7.77 log CFU/g. On the other hand, neither *S. enterica* nor *L. monocytogenes* showed any significant growth on fresh-cut radish and pineapple at all the temperatures investigated, with those on fresh-cut pineapple exhibiting rapid population decline. Temperature abuse can foster the proliferation of pathogens in fresh-cut fruits and vegetables. This study showed the potential for *Salmonella* and *L. monocytogenes* survival and growth at a variety of temperatures on cut cantaloupe, watermelon, honeydew, pineapple and radishes, highlighting the importance of maintaining an uninterrupted cold chain for TCS (temperature control for safety) foods and the need for strict controls to prevent or minimize the presence of pathogens before, during, and after the processing of these fruits and vegetables.

**Survival of E. coli in Manure-amended Certified Organic Soils and Transfer to Tomatoes, Radish, and Spinach in Maryland Eastern Shore**

(*Poster Board #232*)

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Organic fresh produce growers often use raw animal manure to improve and maintain soil quality, fertility and thus productivity. However, untreated, i.e., raw, animal manure used as soil amendment can result in contamination of fresh produce by pathogenic microorganisms that can cause foodborne illnesses. Contamination can occur at any stage throughout fresh produce production and processing. Concerns about potential produce contamination by foodborne illness pathogens, led the National Organic Program to require a 90-day wait time between soil amendment application and harvest for produce not in direct contact with soil, e.g., staked tomatoes and pepper. For produce in direct contact with raw manure-amended soils, a 120-day wait time before harvest is stipulated in the regulation. In this study, the survival of *Escherichia coli* in organic soils amended with raw animal manure were inoculated with a three-strain cocktail of non-pathogenic, rifampicin-resistant *E. coli* (rif-EC) at 6 log CFU/mL (1-L per 2m² plot). A randomized complete block design with 4 replications for each of 4 treatments: horse manure (HM), dairy manure (DM), poultry litter (PL) and unamended (UnA), were established at the University of Maryland Eastern Shore Research Farm. Soils were analyzed on days 0, 7, 14, 28, 60, 90, and 120 pre- and post-inoculation. Transfer of EC to tomatoes, spinach, and radish was determined at 90 and 120 days post-application of manure and EC inoculum. The EC survival was higher and more persistent in the PL-amended soils, than in any other treatment. In all tomato plots, yellow-striped army worms invaded and caused major crop damage by day 90, and were suspected of contributing to the large number of EC-positive tomato fruits when assayed. Spinach did not mature before frost set, and radishes from all treatments, except UnA, had surviving EC in the initial wash water of the bulbs. This study provides useful information for advancing microbial food safety in fresh organic produce and paves the way for future evaluations of the microbiological and physico-chemical factors in the manure-amended soils that contribute to persistence and/or die-off of the inoculated EC strains.

*Specified Source(s) of Funding: USDA-NIFA*

**Plant Water Stress Limits the Growth of Salmonella on Lettuce**

(*Poster Board #233*)

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The human enteric pathogen *Salmonella enterica* subsp. *enterica* can colonize leafy greens and cause foodborne illness on consumption. *Salmonella* can thrive on plant surfaces by utilizing nutrients from surfaced-leached exudates. Our previous work reported that the presence of various specialized (secondary) metabolites is negatively correlated with the growth of *Salmonella* on tomato surfaces. When plants are under water stress, they are likely to synthesize more specialized compounds. The purpose of this study was to evaluate the effect of water stress on the growth of *Salmonella* on lettuce leaf surfaces. Four-week-old lettuce plants (red loose leaf lettuce cultivar ‘Mascara’ and Romaine lettuce ‘Parris Island Cos’) were subjected to water stress for 6 days, or watered regularly (control). Colonies of *Salmonella* Newport and Typhimurium adapted for rifampicin resistance were grown overnight on tryptic soy agar (TSA) at 35 °C , then suspended in 0.1% Peptone Water (PW) to a concentration of 10^7 CFU/mL. Aliquots (100 µl) of the cell suspension were inoculated onto the abaxial side of each leaf. The inoculated leaves on each plant were clipped 24 hours post-inoculation (hpi), and put in a Whirlpak bag with 30 ml of 0.1% PW. Serial dilutions from the rinsate were plated onto TSA with rifampicin for bacterial enumeration. Population levels of *Salmonella* retrieved from water-stressed and control plants differed. The survival of *Salmonella* were significantly lower on red loose leaf lettuce than Romaine lettuce. For the red loose leaf lettuce, when leaves were inoculated with ~6.0 logCFU/mL
Salmonella*, the number of Salmonella Newport cells recovered from water-stressed plants after 24 hpi was $1.6 \pm 0.2 \log_{10} \text{CFU/mL}$, compared to control plants at $2.4 \pm 0.2 \log_{10} \text{CFU/mL}$ ($P < 0.05$). Salmonella Typhimurium recovered from water-stressed plants was estimated at $1.3 \pm 0.3 \log_{10} \text{CFU/mL}$, while the level on control plants was $2.2 \pm 0.3 \log_{10} \text{CFU/mL}$ ($P < 0.05$). These data suggest that lettuce plants responding physiologically to water stress may provide a less favorable environment for Salmonella colonization. Cultivar also plays a role in limiting the growth of Salmonella. Understanding how human pathogen-plant interactions are affected by extreme fluctuations in climate is important as climate variability increases.

**Fruit Quality and Volatile Compounds of Specialty Muskmelon As Affected by Grafting under Organic Fertilization and Plant-growth-promoting Rhizobacteria Management**

*(Poster Board #234)*

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While interspecific hybrid squash rootstocks are effective in managing soil-borne diseases in grafted melon production, their adverse impacts on fruit quality remains a major concern. This study was conducted to examine the influence of grafting with an interspecific hybrid squash rootstock on fruit quality modification, including volatile compounds, in muskmelon (Cucumis melo) under different field management systems. A specialty muskmelon ‘Tasty Bites’, developed from a cross between ‘Charentais’ and ‘Ananas’ melons, was grafted onto a Cucurbita maxima × C. moschata rootstock ‘Super Shintosa’ with organic or conventional fertilization, with or without application of plant-growth-promoting rhizobacteria (PGPR). The field trial was carried out during the 2016 spring season in Citra, FL. A split-plot design with four replications was used with the fertilization system and PGPR treatment combinations in the whole plots and grafted vs. non-grafted plants in the subplots. Fully ripe fruit were sampled for quality assessment. Glucose content was significantly higher for organic than conventional fertilization, whereas conventional fertilization resulted in a significantly higher fructose content. The PGPR decreased fruit glucose content, but led to higher sucrose. Fertilization and PGPR showed significant interaction effects on the sugar profile of melon fruit. Flesh firmness of melons decreased under PGPR application or organic fertilization and it was also affected by the interactions among grafting, fertilization, and PGPR. Treatment effects were not observed in fruit soluble solids content, pH, or titratable acidity. Fifty-six volatile compounds were detected, including mainly esters, alcohols, and aldehydes. Non-grafted melons with organic fertilization plus PGPR had the lowest levels of total volatile compounds and esters. Although grafting did not show a significant main effect on total volatile and ester contents, it significantly increased the levels of certain ester compounds such as ethyl propionate, butyl acetate, amyl acetate, prenyl acetate, furfuryl acetate, hexyl acetate, isoamyl butyrate, and benzyl formate. Melons from grafted plants had higher contents of total aldehydes and alcohols than non-grafted melons. In contrast, other volatile compounds such as allyl methyl sulfide were lower in the grafted melons. Overall, grafting appeared to exhibit greater impacts on melon volatile compounds compared with fertilization and PGPR treatments. Future research is warranted to determine the influence of melon volatile profile modification by the C. maxima × C. moschata rootstock on fruit flavor and other sensory properties perceived by consumers.

**Influence of Silver Nanoparticles on Health Promoting Compounds of Watermelon**

*(Citrullus lanatus (L.) (Poster Board #235)*

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Nanotechnology has the potential to revolutionize the food industry by enhancing productivity, resource efficiency, nutritional quality, and consumer-preferred functional (health-promoting) properties in a cost-effective manner. In this study, we investigated the impact of nano-based seed priming on productivity and accumulation of health-promoting compounds (ascorbic acid, lycopene, and L-citrulline) in watermelon. Silver nanoparticles (AgNPs) were synthesized using onion bulb extracts which have been shown to activate seed phytohormones as well as to stimulate physiological processes and growth. The AgNP-delivery system was used to prime seeds of two watermelon varieties namely: Riverside (diploid) and Maxima (triploid). AgNP priming was compared with a turmeric oil nanoemulsion while dry unprimed seeds were used as controls. Following seed priming, seedlings were raised in a greenhouse and later field-transplanted at four locations within Texas; Edinburg, Pecos, Grapeland, and Snook. An increase in lycopene, total ascorbic acid, and L-citrulline contents was observed in fruits of Riverside nano-primed with AgNPs. Total ascorbic acid was increased by 54.6% (Snook), 25% (Grapeland), 10% (Edinburg), and 7% (Pecos) when compared to controls. L-citrulline levels increased up to 62% in fruits

An asterisk (*) following a name indicates the presenting author.
of AgNPs treated plants grown in Pecos. Similarly, lycopene content in fruits of AgNPs-treated Riverside seeds were relatively higher in all the locations compared to the control. No consistent changes in nutritional levels were observed in fruits of Maxima. Similarly, seed treatment with turmeric oil nanoemulsion did not have any significant effects on fruit quality of both varieties. These observations suggest that seed priming with AgNPs as a delivery system has a potential to enhance postharvest fruit functional quality and that outcomes could depend on cultivar, ploidy level, as well as production location. Further investigations are needed to characterize these interactions.

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**Sensory Evaluation of Methyl Jasmonate Treated Raw and Steamed Broccoli (Poster Board #236)**

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Application of methyl jasmonate (MeJA) has been reported to enhance the potential health-promoting compound, glucosinolates (GS), especially inducible indole GS-neoglucobrassicin by mimicking insect damage. When plant cells are ruptured, myrosinase hydrolyzes GS into its hydrolysis product that may impact consumer acceptance of brassica crops even though myrosinase is usually inactivated during cooking. To our knowledge, there is no report on the consumer acceptance and sensory evaluation on MeJA-treated broccoli (insect-damaged produces). The aim of this study was to determine if an untrained consumer panel can detect differences between control and 250 μM MeJA treated broccoli (raw or steamed 4 min) using sensory evaluation (triangle test, attribute test, and preference test). To further associate the phytochemical profiles with the sensory evaluation, we measured the change in GS, GS hydrolysis profiles, and primary metabolites from broccoli tissue. Results of the triangle test showed that panelists were able to correctly identify the odd raw broccoli samples (P < 0.05) but not the odd cooked broccoli samples (P > 0.05), which is consistent with attribute and preference test results. While there was no significant difference in appearance, the raw control broccoli was rated more favorably in taste, texture and overall liking (P < 0.05). On the other hand, panelists showed no preference between steamed MeJA-treated and steamed control broccoli in any of the attributes tested (P < 0.05). MeJA treatment significantly induced neoglubrassicin compared to the control broccoli (7.6-fold) and this increment was observed after steaming as well (7.8-fold). MeJA treatment also significantly decreased total aliphatic GS concentration by 25%. N-methoxyindole-3-carbinol and N-methoxyindolyl-3-carboxaldehyde, neoglubrassicin-derived hydrolysis products were significantly increased 7.6-fold and 2.4-fold in raw MeJA-treated compared to raw control broccoli. There was significantly less serine in raw MeJA-treated compared to raw control broccoli; however, after steaming the level of galactose, citric acid, and serine was not statistically different between control and MeJA-treated broccoli. Steaming significantly reduced total neoglubrassicin in control (22.3%) and MeJA-treated broccoli (20.5%) compared to raw broccoli. N-methoxy indole-3-carbinol was decreased by 89.8% (control) and 96.2% (MeJA treatment). Notably, N-methoxy indole-3-acetonitrile was under detection limit in both samples. The decrement of hydrolysis products may result from deactivation of endogenous myrosinase during steaming; therefore, the hydrolysis process was interrupted. This study showed that consumer attribute testing was less favorable toward MeJA-treated raw broccoli; however, cooking the broccoli negated this effect. Partial least square regression model indicates that N-methoxyindole-3-carbinol, N-methoxyindolyl-3-carboxaldehyde, and N-methoxyindole-3-acetonitrile are the most important on sensory quality.

**Desirable Light Intensity for Growing Lactuca indica As Leafy Greens in Controlled Environment System (Poster Board #237)**

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The young leafy greens of lettuce have higher levels of vitamins, minerals, antioxidants, and other nutrients than the older mature vegetables on a unit fresh weight basis. The usage of baby leaf and microgreen vegetables as salads and food toppings is on the rise especially in South Korea where smaller family sizes and single-person homes are increasing. *Lactuca indica* ‘Sunhyang’ is a cultivar developed from a wild species native to Korea that has desirable flavor, aroma, and a short growing period from seed to harvest. The purpose of this research was to determine the optimum light intensity for growing this plant cultivar as baby leaf greens and to characterize the accumulation of phytochemicals under various light levels. Seeds were sown in a standard horticultural root substrate. Upon seed germination, the seedlings were exposed to 100 μmol·m⁻²·s⁻¹ artificial light for 14 days. When the seedling plants were 6.2 cm tall on the average with 2.9 true-leaves, they started to receive four different levels of light (50, 100, 250, 500 μmol·m⁻²·s⁻¹) for 21 days in a controlled environment facility (plant factory). The average desirable plant height was set at 10–12 cm. Starting from 6 days after light treatment began, measurements on plant growth, hunter ‘a’ value, anthocyanins, phenolics, and chlorophyll were made 6 times at 3-day intervals. The time required for seedlings to reach the desired plant size and actual fresh weights were:
For the highest concentrations of functional food ingredients, it is recommended to grow the plants under 500 µmol·m⁻²·s⁻¹ light intensity for 15 days.

Seasonal Difference in Nutritionally Important Carotenoid Pigment Concentrations in Microgreens Grown in Controlled Environments (Poster Board #239)

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Brassica, lettuce, and herbal crops are the most commonly grown microgreens due to their simple cultivation, quick germination and short production cycles. Microgreens are increasing popular among consumers, and are especially suitable for greenhouse and controlled environment production. Special leafy vegetable crops can be excellent sources of carotenoid phytonutrients, which possess reported health benefits of reducing cancers, cardiovascular disease, and aging eye diseases when regularly consumed in the diet. The objective of this study was to screen fifteen commercially available microgreen cultivars across several greenhouse production seasons for accumulation of nutritionally important carotenoid pigments. Five cultivars each of lettuce, herb, and brassica crops were grown under greenhouse conditions using a soilless peat mix in solid-bottom plastic trays (26 × 52 × 3 cm) and misted daily using a fine spray nozzle head. Dates and average growing conditions for greenhouse grown microgreen cultivars were: winter (Jan.–Feb.; DLI, 14 mol·d⁻¹; air temperature, 20 °C); spring (Mar.–April; DLI, 32 mol·d⁻¹; air temperature, 22 °C); summer (May–July; DLI, 40 mol·d⁻¹; air temperature, 25 °C); and fall (Aug.–Sept.; DLI, 36 mol·d⁻¹; air temperature, 27 °C). Shoot tissues were harvested after cultivars reached the first to second leaf stage. Samples were frozen at –80 °C, freeze-dried, and measured for concentrations of β-carotene, lutein, and zeaxanthin pigments using HPLC. Data were analyzed using mixed model in SAS. β-carotene, lutein, and the total concentration of carotenoids pigments within the brassica and lettuce species were influenced by season (P ≤ 0.001), cultivar (P ≤ 0.001), and the interaction of season by cultivar (P ≤ 0.001). β-carotene, lutein, and the total concentration of carotenoids pigments within the herb species were influenced by season (P ≤ 0.001) and the interaction of season by cultivar (P ≤ 0.001). Carotenoid pigment concentrations were higher during the summer and fall seasons when DLI and air temperatures were higher for the brassica, lettuce and herb microgreens and lowest in the winter and spring seasons when average DLI and air temperatures were lowest. With the increasing popularity of microgreens, information on the impacts of cultivar selection and growing conditions on nutritional values would be useful information for producers serving local food systems.

Composition of Hollow Heart Flesh in Grafted and Non-grafted Liberty Seedless Watermelon (Poster Board #240)

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Triploid (seedless) watermelon is a fruit of great economic importance. However, seedless watermelon cultivars tend to be more susceptible than diploid (seeded) watermelon cultivars to internal defects such as hollow heart (HH). HH is characterized as an internal crack or void developing in the center of the fruit. Watermelon are required as pollinator plants in seedless watermelon production. Incomplete pollination plays a crucial role in the development of HH. Watermelon cultivars that have less dense flesh also tend to be more prone to HH; however, the effect of rootstock (rs) on HH is unknown. Experimental objectives were to induce HH formation in watermelon, assess rootstock influence, and determine quality. Liberty, prone to HH, was the scion grafted onto four treatments; no graft (control), Carnivor and Kazako (interspecific hybrid rootstock, C. moschata × C. maxima), and Emphasis (Lageneria siceraria, bottle gourd rs). Fruit were cut longitudinally and rated for HH incidence, void airspace and tissue firmness. Firmness was measured with a FDIX penetrometer with 0.8 cm diam. probe in heart and interlocular flesh tissue spaces. Flesh firmness was increased by 1 N in fruit of interspecific rs and fruit with no HH. Sugar content (%fructose, %glucose and %sucrose) of heart tissue was strongly and positively correlated to pH. Fruit from Emphasis rs had the highest %glucose and total sugar content (P < 0.05). HH incidence and graft rs had no effect on lycopene, citrulline, or arginine content. Confocal micrographs were used to count the number and area (μm²) of cells in fruit rated no, moderate, and severe HH. At least 750 cells were measured in fruit using ImageJ software. The number of cells was not affected by grafting or HH severity; the average cell area was largest for fruit of Emphasis rs with a average cell area at 110,805 μm². Fruit with moderate HH also had a larger cell area (102,873 μm²). Fruit of Emphasis rs showed decreased tissue firmness and increased in total sugar content. Although fruit with HH tended to have higher total sugar content, no significant differences were seen compared to fruit with no HH. Interspecific hybrid rs increased watermelon tissue firmness and cell density and decreased HH incidence. Fruit were more susceptible to HH when total sugars were higher and firmness/cell density were lower. HH can be field-induced in susceptible watermelon cultivars, and in contrast, HH may be reduced with rs of some interspecific hybrids.  

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Tropical Horticultural Crops (Poster)

Conversion Efficiency of Organic Ginger Rhizomes to Seedlings As Affected by Presprouting Covers (Poster Board #379)

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Ginger (Zingiber officinale, Roscoe) is a high antioxidant spice crop grown for its rhizomes which are used as condiments in various dishes, as medicinals, and as antimicrobials. Native to tropical Asia, it is an herbaceous perennial, which is propagated directly from rhizome pieces that grow optimally in the extended growing season. Under short season conditions, its development is limited, but it has been produced from seed pieces or multi-tillered seedlings derived from rhizome pieces of about 60–120 g. However, there is the potential to increase the number of seedlings derived from seed pieces and the need to determine if pre-sprouting storage of the rhizomes affect budding and seedling production. Thus, a study was conducted to determine if storage of organic ginger rhizomes in organic mix or paper prior to propagation had any influence on sprouting and seedling production. Organic ginger rhizomes harvested in late fall, were covered in organic mix or paper and kept at 20 to 23.2 °C for 4 months until they were removed for propagation in a greenhouse. The growing environment was organic mix in flats where the temperature ranged from 22.2 to 36.1 °C. The study was conducted as a completely random design with the covers as treatments and three replications. Neither paper nor an organic mix cover affected the number of buds produced prior to propagation, or number of sprouts produced after propagation. Seedling sprouting occurred slowly over the first month. After nine weeks, the average rhizome weight required to produce a seedling, (conversion efficiency) was 50 g or less. The results indicate that producing multiple seedlings from rhizome pieces may be feasible for producing ginger, particularly, if the seedlings can be started early to give a head start on their tiller number when transplanted.

Specified Source(s) of Funding: Evans Allen

Developing a Production Guide for High Elevation Strawberries in Tropical Timor-Leste (Poster Board #379)

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During the past two years, small-acreage growers on the tropical and mountainous island nation of Timor-Leste have initiated strawberry (Fragaria ×ananassa) production as a potential market for fresh, locally-grown berries, and to increase grower profitability and sustainability. Strawberries are a cool weather crop requiring relatively colder temperatures to increase plant growth, crown production and subsequent berry yield. In tropical Timor-Leste, therefore, strawberry production can only succeed at high elevations (1000–1500 m). Strawberries are currently produced in high tunnels, greenhouses, and open fields. However, growers have had little country-appropriate production information to aid their pursuits. Accordingly, a project funded by the United States Agency for International Development (USAID, known as the USAID’s Avansa Agrikultura Project)
in collaboration with Cardno Emerging Markets USA and the Borlaug Institute for International Agriculture at Texas A&M University was initiated to produce a strawberry production manual, as well as train district agricultural agents in strawberry production. Travel to Timor-Leste by the senior author occurred during 15-30 Aug, 2017, to visit producers, document their needs and production issues, diagnose crop, and field problems, and create the production manual. The assessment indicated that strawberry growers in Timor-Leste are capable of quality and profitable production; however, a lack of basic production knowledge, sufficient growing experience, and significant crop issues limiting high production were observed. Currently, common leaf spot (Mycosphaerella fragariae) is an increasing concern. Results of the visit were summarized, district agents trained and recommendations for country-appropriate techniques were developed and published in the USAID’s Avansa Agrikultura Project booklet titled: Strawberry Production in Timor-Leste: Good Agricultural Practices Manual. Overall results of the in-country assessment and publication of the manual will be summarized and presented.

Specified Source(s) of Funding: USAID

**Ionic Responses of Papaya and Sapodilla Plants to Two Forms of Root-Zone Salinity**

*(Poster Board #380)*

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Root-zone salinity was provided to Carica papaya ‘Sunrise’ (papaya) seedlings and grafted Manilkara zapota ‘Pondorosa’ (sapodilla) plants as diluted ocean water or NaCl solution in order to determine the ionic responses of root, stem, and leaf tissues. Sand culture was employed and the two salinity treatments were supplied to the intolerant papaya plants at 8 dS⁻¹ and to the tolerant sapodilla plants at 20 dS⁻¹. The control plants received dilute nutrient solution at 1 dS⁻¹. All experimental units were harvested after 6 weeks of exposure for papaya or 10 weeks of exposure for sapodilla. In papaya, sodium concentration of leaves was greater for ocean water than for NaCl, and chloride concentration of leaves was greater for NaCl than for ocean water. In sapodilla, sodium concentration of leaves was similar between the two salinity treatments, but chloride concentration of leaves was greater for ocean water than for NaCl. Compared to control plants, sodium:potassium of papaya leaves increased 25-fold for NaCl and 41-fold for ocean water; and sodium:potassium of sapodilla leaves increased 5-fold for NaCl and 10-fold for ocean water. Other leaf stoichiometric traits such as nitrogen:phosphorus and nitrogen:potassium were also dissimilar between the two forms of salinity. For both species, root and stem sequestration of sodium was greater in ocean water plants, but root and stem sequestration of chloride was greater in NaCl. These results indicate that previously published analyses of ionomics following exposure to NaCl do not sufficiently reflect true ionomics of plants exposed to salinity stress associated with oceanic coastal environments. The covariance structure of essential nutrients within plant tis-

**Nutrient Levels in Date Palm (Phoenix dactylifera L) and Ornamental Phoenix Spp.**

*(Poster Board #381)*

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Nutrient concentrations of date palm (Phoenix dactylifera L) cv ‘Barhee’, ‘Deglet Noor’, ‘Khadrawy’, ‘Khalasa’, and ‘Medjool’ were compared with the breeding line ‘Deglet Noor BC5’ and ornamental Phoenix spp P canariensis, P roebelinii, and P reclinata. All palms were mature trees growing in a genebank maintained by the United States Department of Agriculture in a low desert environment and all received similar cultural care. Leaves were sampled as previously described and analyzed for total N, P, K, S, B, CA, Mg, Zn, Mn, Fe, and Cu. Concentrations of all nutrients studied, except for Mn and Cu, differed significantly (P > 0.05) between accessions. In general, macronutrient concentrations tended to be higher in the ornamental species than in P dactylifera but this was not true for all P dactylifera cultivars due to variations in macronutrient concentrations between P dactylifera cv. Regarding micronutrients, the differences in concentrations between P dactylifera cv were less pronounced than for macronutrients. Nutrient concentrations in P canariensis tended to be similar to P dactylifera, but were more variable and lower in P roebelinii and P reclinata, particularly with regard to micronutrients. These results may be useful in assessing nutrient status of production date palms and of ornamental Phoenix spp.

**Influence of Cover Crops Integration on Newly Established Abaca (Musa textilis Nee)Crop Growth and Soil Health in Eastern Central Philippines**

*(Poster Board #384)*

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Cover crops provide potential benefits to crop production, soil and water quality, and soil health. They can greatly reduce soil erosion, capture and cycle nutrients, increase soil organic carbon,
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water infiltration, and microbial biomass, influence microbial diversity, reduce greenhouse gas emissions, and suppress weeds. However, major challenges of adopting cover crops include plant establishment, species selection, soil moisture management, and cover crop termination. We hypothesized that planting cover crops would provide vegetative cover during abaca establishment and maintain soil health but not negatively affect abaca growth. The objectives of this study were: a) to determine if cover crops could be established under abaca; b) examine cover crop growth and biomass production of different species (broadleaf versus grass); c) determine total nitrogen in cover crops and soil; and d) evaluate abaca growth to determine (positive, negative, or neutral) impact of cover crops. Cover crops [peanut (Arachis hypogaea), mung bean (Vigna radiata), and upland rice (Oryza sativa)] were seeded three weeks after transplanting of tissue cultured abaca. Peanut produced greater biomass (3.38 t·ha⁻¹) than mung bean (2.59 t·ha⁻¹) and upland rice (1.86 t·ha⁻¹). The total nitrogen and total carbon of cover crops averaged about 3% and 40%, respectively, regardless of species. Soil microbial biomass averaged about 520 µg·g⁻¹ C soil at 0–15 cm, and 396 µg·g⁻¹ soil at 15–30 cm soil depth, and was similar among all treatments. Abaca growth parameters such as plant height, stem diameter, and number of leaves, were similar among control (no cover crop) and cover crop treatments. These results demonstrate that different cover crop species can be integrated successfully under abaca production system while maintaining abaca growth. These cover crops may be extremely important to help with erosion control especially during establishment.

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Classification of Macadamia Cultivars Using Near Infrared Spectroscopy (NIRS) and Multivariate Analysis (Poster Board #385)

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Brazil is the seventh largest macadamia producer in the world with a cultivated area of 6500 hectares. The main existing macadamia cultivars were introduced from Hawaii Agricultural Experiment Station (HAES) and some were selected by Instituto Agronômico de Campinas (IAC) based on Hawaiian cultivars. Although growers can recognize macadamia cultivars based on nut appearance and morphology, some cultivars produce nuts quite similar to each other, which makes difficult to classify the fruit. As near infrared spectroscopy (NIRS) has been used to classify various food produces, the objective of this study was to evaluate the feasibility of near infrared spectroscopy (NIRS) to classify intact shelled macadamia nuts. A total of 255 shelled macadamia nuts were collected from the following cultivars: IAC 4-20 ‘Keaumi’ (n = 80), IAC 5-10 ‘Kakeré’ (n = 60), IAC 8-17 ‘Waiaré’ (n = 80), IAC 2-23 ‘Keudo’ (n = 40), HAES 246 ‘Keauhou’ (n = 80). Two spectra were acquired per nut using a NIR spectrometer (Tango, Bruker, Ettlingen, Germany) in the reflectance mode over the wavelength range of 11,544–246 cm⁻¹ with 15–30 cm soil depth, and 64 scans. Different pre-processinges were applied to spectra, namely standard normal variate (SNV), De-trend, multiplicative scatter correction (MSC), and first derivative of Savitzky-Golay. Spectra were subjected to principal component analysis (PCA) and partial least squares discriminant analysis (PLS-DA) and models were developed for each cultivar. The best results were obtained for the cultivars IAC 4-20 ‘Keaumi’ (SEP = 0.24%, R² = 0.68, with 9 LVs) and IAC 2-23 ‘Keudo’ (SEP = 0.19%, R² = 0.68, with 11 LVs). The other cultivars could not be separated from each other due to genetic similarities (progeny). These results indicate that NIR spectroscopy can be useful for the classification of macadamia cultivars based on their nuts and could be a valid and simple tool to reduce the quality control costs of monitoring macadamia nuts’ quality. However, is recommended more experimentation to include more data variability in order to increase the classification accuracy to 100%.

Specified Source(s) of Funding: CAPES

Vegetable Breeding 2 (Poster)

A Large Genotype-environment Interaction for Challenging Adaptation Traits Promises Greater Genetic Gain in Breeding Broccoli Adapted to Eastern Growing Conditions (Poster Board #047)

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Expansion of broccoli production in the eastern United States requires adapted varieties. They have not been available because commercial breeders found adaptation too hard to breed for. The eastern environment is notable for greater variation in temperature and water, with warm and humid nights during the growing season. Traits for adaptation include temperature sensitivity of growth and reproductive development. Rapid, uniform but not excessive vegetative growth despite transient excesses of temperature and water, coordinated flower bud development through elongation and arrest at a small size, ability to shed rainwater, and resistance to purple sepals from sunburn or cold. Some of the traits have been difficult to select for because heritability is low. There are two possibilities for the low heritability: the variation is largely due to environment, or traits are expressed only in specific environments where selection was not done. If the latter is true, breeding by selection has good promise. In both cases the main effect of genotype would be relatively low, but only in the latter case would genotype-by-environment interaction be large (as long as some of the environments produced genotype-dependent variation). Breeding lines that showed promise an initial screen replaced in replicated trial consisting of 20 environments (five planting dates at each of four locations—Maine, New York, North and South Carolina). Four control entries were consistent in each of four years, with 8–13 entries changing annually as new hybrids were produced by breeders and whose promise was identified in screening. The traits were evaluated on a referenced scale with the raters at each site trained to use the scale in the same way. A particularly difficult trait to improve has been temperature sensitive delay of floral development. This defect occurs when insufficient low temperature exposure temporarily arrests development of reproductive meristems and floral primordia, and causes the flower buds to vary in size at harvest maturity. We scored that trait as “bead uniformity.” In the four years, genotype explained 11, 7, 3 and 21% of the total variance. Genotype by environment accounted for 18, 20, 24, and 18.5% of the total variance. The greater contribution of the interaction indicates that the trait can be improved by selecting in the right environment. The comparable numbers for High Dome were lower, with G = 6, 8, 7, 17% and GxE = 15, 12, 13, 28%.

**Understanding Salt Tolerance in Lettuce**
*(Poster Board #048)*

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Salinity is a concern in the major lettuce growing districts in California and will be increasingly important. Lettuce is sensitive to salt stress, which reduces biomass and causes other undesirable effects. We sought to identify physiological traits, proteins and genes important in salt tolerance that can be selected for and introduced in new cultivars in order to adapt to high salinity without affecting productivity. Following up on information from previous salinity tolerance studies, crisphead lettuce cvs. Laura and Early Bird were chosen for more detailed analyses. The cultivars were evaluated in a growth chamber at 20 °C, 50% relative humidity, 250 µmol/m²/s continuous light and Hoagland nutrient solution without or with NaCl and CaCl₂. Salt concentration in the salt treatment started from 0 mM/0 mM NaCl/ CaCl₂ (2100 µS/cm) at the time of seeding and was gradually increased every week to 30 mM/15 mM NaCl/CaCl₂ (8600 µS/cm) to prevent salt shock. These high salt concentrations are non-lethal, permissive to lettuce growth and representative of salt concentrations commonly observed in areas of high salinity. We measured leaf chlorophyll content, photosynthetic CO₂ assimilation, leaf transmittance, photosynthetic efficiency (Fv/Fm) and fresh weight at the end of the 4-week growth period. Shoot and root tissues were harvested for detailed analyses, including quantitative proteomics. Plants in the growth chamber produced significantly more shoot biomass compared to previous salinity-tolerance studies conducted in the greenhouse, and more clearly expressed phenotypic differences between control and salt treatments. Salt-sensitive ‘Laura’ had a much larger decrease in shoot mass compared with the salt-tolerant ‘Early Bird’. Salinity significantly increased chlorophyll content and photosynthetic CO₂ assimilation, but did not affect Fv/Fm in sensitive and tolerant lines. This contrasts with observations in other crop and model plants in which salt stress significantly decreases chlorophyll, photosynthesis, and Fv/Fm. The physiological responses of ‘Laura’ and ‘Early Bird’ to salinity are interesting for further studies that could identify unique adaptations in lettuce that may be important in salt tolerance. 1472 proteins from ‘Laura’ and 975 from ‘Early Bird’ were identified using quantitative isobaric peptide labeling, off-gel fractionation, and LC/MS/MS analysis. Twenty-eight proteins were upregulated and 31 downregulated significantly in ‘Laura’, while in ‘Early Bird’, five were upregulated and eight downregulated significantly in high-salt treatment compared to control. We are currently conducting similar analyses in lettuce cultivars from other lettuce types to identify physiological traits, proteins and genes that are important for salinity tolerance.

*Specified Source(s) of Funding:* California Department of Food And Agriculture

**Reduced Seed Count Improves Versatility of Specialty Snack Peppers** *(Poster Board #049)*

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Small/miniature sweet and hot peppers (*Capsicum annuum* L.) are a rapidly growing class of specialty peppers. The peppers are popular among consumers because of their versatility, snackability, vibrant colors and their nutrition attributes. While field production of traditional pepper commodities is in decline in parts of the country, other parts including snack peppers are expanding greenhouse acreage for high-value specialty pepper production. A relatively small number of commercial snack cultivars with acceptable uniformity have been developed. Additional research is needed to improve product uniformity, fruit quality and shelf-life. Low seed count is an important attribute...
for consumer acceptance of snack peppers. Seed count within populations exhibiting small round, blunt, and lobed snack size pods was scored and typified by several discrete classes defined by high, reduced and low seed numbers. Seed count was not correlated with fruit shape and segregated independent of pod type. Inheritance of low seed count in the specialty snack pepper market will be discussed. Our results demonstrate that via extensive selection, low seed count can be combined with snack size pods, superior fruit shape, thick pericarp, and sweetness on plants with compact habit for garden culture and on large stature plants that maximize yield for commercial production.

**Fine Mapping of the Genic Male-sterile Gene (ms3) in Chili Pepper (Poster Board #050)**

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In South Korea, most of peppers (Capsicum annuum L.) are F1 hybrid varieties, which are superior to homozygous varieties in all characteristics such as high uniformity, high productivity, and strong resistance to biotic/abiotic stress. Genic male sterility (GMS) is one of the most used methods for the economic production of hybrid seeds. A GMS gene ms3 is known for being used to develop the European pepper varieties. The previously developed GMS3-CAPS marker is closely linked to the ms3 gene. However, it has some problems including no polymorphism, presence of repulsion phase, and existence of recombinants, because it is just the trait-linked marker. Therefore, in this study, we constructed a fine map of ms3 gene to develop gene-based markers. A total of 119 primer sets for high-resolution melting (HRM) analysis were designed based on the SNPs identified by next generation sequencing (NGS) analysis in the previous study. As a result, a total of 54 HRM markers were developed. Of them, 14 HRM markers were cosegregating with the phenotypes of 332 individuals segregating into male-fertile (MF) and male-sterile (MS). This fine mapping approach revealed the ms3 gene is positioned within a region of 207.3 kb on chromosome 1, including three candidate genes. This information will be helpful to develop the ms3 gene-based markers.

Specified Source(s) of Funding: AFRI-USDA

**Mapping Quantitative Trait Loci Controlling Fruit Morphology and Color Parameters in Intra-specific RIL Population of Tomato (Poster Board #052)**

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Tomato (Solanum lycopersicum L.), is world’s second most consumed vegetable after potato and cultivated throughout the world. The market value and culinary purposes of tomato are often determined by its appearance and morphology. Genetic characterization of such morphological and appearance traits in intra-specific population will aid in their genetic improvements without any limitation by linkage drag. Objective of this study was to identify the QTL associated with fruit shape, size and color of tomato. QTL analysis for these traits was performed in an intra-specific population of tomato developed from a cross between NC-22L-1(2008) x NC 30P consisting of 110 recombinant inbred lines (RIL). A linkage map with 886 single nucleotide polymorphism (SNP) molecular markers was constructed covering 739.5 cM of 12 chromosomes of tomato, with an average of 0.83 cM between markers. The total of 35 fruit morphology attributes and nine color attributes based on RGB color space (Red, Green, Blue) and CIELAB color space (L*, a*, b*), including two color descriptors (Hue and Chroma) were

An asterisk (*) following a name indicates the presenting author.
A SNP-Based Genetic Map of Bulb Onion Using Its Transcriptome Sequences As a Reference and Genotyping-by-sequencing Analysis (Poster Board #053)

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Genetic linkage maps of bulb onion (*Allium cepa* L.) remain relatively rudimentary despite its economic significance as one of the most important vegetable crops globally. It is very difficult to study on genomics and genetic mapping of onion due to large genome size (16.3 Gbp), biennial life cycle, cross-pollinated habit, and high inbreeding depression. High-density genetic maps of onion are inevitably required for completion of its whole genome reference and development of molecular markers associated with traits of interest. In this study, we attempted to generate a high-density genetic map of onion using an *F*₂ segregating population derived from a cross between a DH line ‘H6’ and an inbred line ‘SP3B’, and using genotyping-by-sequencing (GBS) analysis. First of all, 101.8 Gbp of raw sequence data and 1 G of reads were generated by Illumina HiSeq 2500. Clean reads of each sample were mapped to the onion transcriptome reference sequences. When the filtering condition was set to the minimum depth of three, a total of 8431 SNPs were detected. Of them, 704 SNPs were positioned on the genetic linkage map consisting of eight linkage groups, and the entire genetic distance was 928.3 cM. In addition, each chromosome number of 8 linkage groups was assigned by comparing with the previously reported onion genetic linkage map, OH1×5225. A total of 248 primer sets for high-resolution melting (HRM) analysis were designed based on common SNPs between H6×SP3B and OH1×5225. A total of 35 polymorphic HRM markers were mapped on the onion genetic map of this study and used for comparison of two genetic maps. Finally, the genetic map covered eight chromosomes with a total genetic distance of 870.4 cM, and contained total 736 markers consisting of 701 SNPs by GBS and 35 HRM markers. This high-density genetic linkage map of bulb onion will be helpful to develop molecular markers for important traits and to accelerate the improvement of onion.

**Taro Breeding at the University of Hawaii** (Poster Board #054)

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For over 70 years the University of Hawaii has been involved in the breeding, selection, and genetic preservation of taro, *Colocasia esculenta* (L.) Schott, is grown worldwide as a staple starch. Known as ‘kalo’ in Hawaii, it has a deep significance to the indigenous people, being an incarnation of the older sibling to humanity in the Hawaiian creation myth. Over 200 landraces of taro were recognized as existing in Hawaii prior to Western contact; however, only around 60 still exist and are maintained in the University’s collections. The globalization of the islands has introduced new cultivars as well as new diseases. Taro Leaf Blight, caused by the oomycete *Phytophthora colocasiae* Racib., is arguably the most damaging disease as it reduces functional leaf area, resulting in reduced corm yield and also less edible leaf vegetable matter. This disease previously resulted in the almost total loss of the Samoan taro crop and export market. Various corm rots also reduce yields, resulting in unsaleable crops and shortened shelf life. Dasheen Mosaic Virus and other viral diseases are also on the rise and have the potential to affect future crop production and quality. To combat these diseases, a succession of researchers at the University of Hawaii have made crosses between native landraces and germplasm from 200 range of countries around Asia and the Pacific; using the latter as sources of resistance and increased genetic diversity for their traditional breeding programs. These have lead to releases of several new cultivars with improved resistance and higher yields. However, some of the earlier releases have been controversial, due to patenting of lines developed from native germplasm and questions raised about indigenous biological sovereignty. The current taro breeding program has built upon some of these previous releases, while respecting indigenous rights, improving agronomic performance, and maintaining high eating quality. While we predominately select for poi quality, we have also evaluated lines for use as steamed “table taro” as well as kulolo—a sort of coconut and taro pudding. The program is working also to foster connections and get feedback from the native Hawaiian community, and we are actively learning from those directly involved in the program as well, including our recently retired breeder Christopher “Popo” Bernabe. Here we present an overview of our breeding process, some historic
cultivar releases, and some of the promising breeding lines we hope to release in the near future.

**Vegetable Crops Management 3 (Poster)**

**Profiling the Phytohormones and Sugars Contents of Orders and Tissues of Kimchi Cabbage Leaves As Affected by Deficit Irrigation (Poster Board #026)**

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This study was conducted to determine the variation in phytohormones and sugar contents of Kimchi cabbage as affected by deficit irrigation treatments. Those biochemicals were elucidated in different leaf orders in terms of both non-head and head formation leaf, and each tissue (midrib white and outer green parts). The abscisic acid (ABA) content of Kimchi cabbage which commenced at the 12 days after deficit irrigation (DI) was higher than that of severe DI treated (commenced after 39 days) in all tested leaf orders and tissues. Diphaseic acid contents of non-heading Kimchi cabbage caused by DI treatments were increased two times compared with that of control. DI treatment enhanced ABA oxidation in Kimchi cabbage leaves. In DI treatment, hydroxy-ABA (conjugation form) content of head formation leaf with green part was greater than other leaf types and tissues, while those results were opposite in non-head formation leaf. The glucose and fructose contents of non-head formation leaves with DI treatment ranged from 40–60 mg/gDW, which was higher than head formation leaves. The fructan contents of all tested leaf types and tissues were improved by DI treatment. Results indicated that drought or water stress might induce oxidation of ABA metabolites and enhance biosynthesis fructans in Kimchi cabbage leaves. In addition, there was variation in reaction to DI treatment in various leaf types and tissues of Kimchi cabbage. Furthermore, that information can be used to develop practical methods for coping with environmental stresses.

*Specify Source(s) of Funding: RDA of Korea*

**Influence of Nitrogen Level and Type of Fertilizer on Yield and Nutrient Content of Cabbage (Poster Board #027)**

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Georgia is one of the leading cabbage (Brassica oleracea var. capitata) producing states in the United States with more than 3500 ha grown annually. Currently, the University of Georgia recommends applying between 196–252 kg·ha\(^{-1}\) of nitrogen (N) fertilizer to grow cabbage in southern Georgia. It is generally recommended to apply one-third of necessary fertilizer at planting with two additional side-dress applications during the season. Recently growers have begun banding liquid fertilizer several times during the season to reduce N leaching and enhance productivity. To determine the validity of current recommendations as well as the efficacy of applying periodic liquid fertilizer throughout the growing season cabbage, ‘Cheers’ was grown during Fall 2016 and 2017 with four levels of fertilizer applied (196, 224, 252, 280 kg·ha\(^{-1}\) N) to the crop. All plots received 56 kg·ha\(^{-2}\) N (5N–4.4P–12.5K) prior to planting. Plots then received a granular (27N–0P–0K, 5% calcium) or liquid calcium nitrate (9N–0P–0K, 14% calcium) applied in two or six side-dress applications during the season. Plants were arranged in a randomized complete-block design with three and four replications in 2016 and 2017, respectively. There were no interactions between year, N level, or application type. Therefore main effects were analyzed. There were no treatment effects on total yield; however, N-level significantly affected early yields of cabbage. In both years plants grown at the 196 kg·ha\(^{-1}\) N level had significantly lower yields for the first two harvests compared to all other N-levels. Leaf tissue nutrient concentrations were generally not significantly affected by N fertilizer levels. However, the liquid calcium nitrate treatments did have significantly higher foliar calcium levels compared to the granular treatments. Study years significantly affected yields, average head weights, and foliar nutrient concentrations. In general plants grown in 2017 had higher foliar nutrient concentrations than those produced in 2016. Total yields were greater in 2016, but earlier harvested yields were greater in 2017. This study suggests that current recommendations are adequate for cabbage production in Georgia; however, early yields may be negatively impacted when utilizing the lowest range (196 kg·ha\(^{-1}\)) of recommended N fertilizer rates.

*Specify Source(s) of Funding: Georgia Vegetable Commodity Commission*

**Evaluation of Growth and Stomatal Conductance of Kimchi Cabbage with Applied Prototype Irrigation System in Open Fields (Poster Board #028)**

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The aim of this study was to evaluate the performance of a prototype irrigation system on growth and transpiration of Kimchi cabbage. The prototype irrigation system (PIS) consisted of wire or wireless soil moisture sensors (FDR type), data logger, output control panel, and solenoid irrigation valves. The initial irrigation points were set by each soil moisture condition (pF 1.2, 1.7, 2.2, and 2.7). At 56 days after transplanting, the fresh weight and leaf area of Kimchi cabbages at pF 1.2 were the greatest among all the tested treatments, while those of pF 2.2 were lowest. The fresh weight at pF 1.2 was increased by 77% in 2 weeks, however that at pF 2.7 was 29%, while the growth of Kimchi cabbage was retarded in scarcity soil conditions applied by PIS. The results for leaf area were similar to fresh weight data. The stomatal conductance of Kimchi cabbage leaves at pF 1.2 was 266.2 mmol·m⁻²·s⁻¹ H₂O, which was the greatest among all the tested treatments. The difference of stomatal conductance was 168 mmol·m⁻²·s⁻¹ H₂O between pF 1.2 and 2.7. Results suggested that PIS can control soil moisture for optimal growth of Kimchi cabbage and it will be feasible for controlling irrigation in open fields.

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Sustainable Ethnic Crops Production on the Delmarva Peninsula (Poster Board #029)
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Demographics on the Delmarva Peninsula are becoming more diverse; hence, the need for small farmers to capitalize on this trend and diversify crop offerings. The goal of this project was to provide research-based production practices for high-yielding ethnic crops that can be grown on the Delmarva Peninsula. Six studies were conducted, at two separate locations at the UMES Agricultural Experiment Station, to examine yield of Brassica rapa cv. Bosai Chinensis (bok choy), Amaranthus viridis Linn (amaranth), and Hibiscus sabdariffa L. (hibiscus), using sustainable production practices. Two varieties of bok choy, Mei Qing Choi F1 and Joi Choi F1, were planted using a complete randomized design with six treatments: 1) control (chemical fertilizer 20:20:20); 2) vermicompost tea and fish emulsion (VCT+FE); 3) poultry litter leachate (PLL); 4) control + Azospirillum (AZO); 5) VCT+FE+AZO; and 6) PLL+AZO) and four replications each. Two fertilizer regimes, biofertilizers and organic fertilizers, were used for amaranth and hibiscus production using a complete randomized design with three treatments and four replications each. The biofertilizer treatments included: 1) control; 2) AZO; and 3) endo/ecto mycorrhizae, (Endo/Ecto), and the organic fertilizer treatments included: 1) control, 2) VCT+FE; and 3) PLL. Bok choy was harvested at the mature stage, amaranth was harvested for thirteen consecutive weeks, and hibiscus calyces were harvested four months after planting. Results showed that the yields for all three crops treated with sustainable fertilizers were not different from the control (chemical fertilizer). The yields of bok choy and hibiscus calyces grown in different locations with different soil properties were significantly different ($P < 0.05$), but those of amaranth leaves were not. At both locations, the yield of the PLL treatment for the amaranth organic fertilizer study, the yield of the AZO treatment for the amaranth biofertilizer study, and the yield of the VCT+FE for the hibiscus organic fertilizer study was higher than the other treatments. The higher yields varied among treatments and locations for the bok choy studies. There was no significant difference between the control and treatments for each study, which indicates that either treatment can be used to produce a quality yield.

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Evaluation of Insecticides for the Management of Rough Sweetpotato Weevil, Blosyrus Asellus (Coleoptera: Curculionidae) in the Hawaiian Islands (Poster Board #030)
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Sweetpotato is an important staple food crop in Hawaii, both for local consumption and export. Insect damage, especially from weevils, is a major production constraint of sweetpotato in the state of Hawaii. Rough sweetpotato weevil is an invasive pest recently detected in the Hawaiian Islands. The immature stages of the weevil gouge shallow groves on the surfaces of the storage roots that adversely affect its appearance, reduce its marketability, and result in wounds that could allow secondary microbial infections. Sustainable pest management practices are limited for this pest, due to its recent introduction in these
areas. As an interim approach, efficacy of four insecticides including one bioinsecticide were compared against a control to manage this pest in the field. Results from two replicated trials indicate that broad spectrum insecticides such as Belay and Carbaryl are effective in managing this pest. Bioinsecticide Beauveria bassiana was not very effective at the tested rate. Planting sweetpotatoes continuously in the same area would likely increase pest pressure in subsequent crop cycles because of the buildup of populations in the field. Cultural practices such as crop rotation and use of clean planting materials should help to reduce the incidence of pests in the field.

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Evaluating Cover Crops and Rhizobacteria on Different Sweet Pepper Varieties to Maximize Fruit Yield in a Semi-Arid Region of Puerto Rico (Poster Board #031)

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Sweet pepper (Capsicum annuum) is one of the most important vegetable crops with high demand for consumption in Puerto Rico and the United States. This crop ranks among the top five vegetables produced on over 700 small farms located mainly in the southern region of Puerto Rico. Over the past decades many factors have contributed to the decline in production of sweet pepper on the island, including changes in rain and drought patterns, lack of improved varieties, inadequate crop management practices, and emergence of new pests that limit production. Therefore, growers have become heavily dependent on consecutive applications of synthetic agrochemicals to maintain higher yields, making their business unsustainable. The objective of this study was to develop a sustainable management system for sweet pepper that integrates a mix of cover crops as a soil amendment and the application of microbial inoculants on varieties of Cubanelle-type sweet pepper that could improve fruit yield while maintaining a healthy soil. During the 2016 growing season the variety SPP9301 had a 20% greater fruit weight than ‘Grenada’ and 18% greater than ‘Key West’. No significant differences were observed due to cover crop or microbial inoculant treatments on sweet pepper yield in 2017. The strategies evaluated give an alternative to small scale farmers to implement a low-input crop management practice that best suits their specific farming system.

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University of Maine Paper Agricultural Mulch Project (Poster Board #032)

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Developing high functioning degradable agricultural paper mulch has been a high research priority at Highmoor Farm. Previous work produced resulted in a commercially viable product that was eventually orphaned by the commercial partner. Initial tests were performed in 2016 with new paper formulations. A randomized complete block experiment was conducted with four replications using eight paper mulch treatments and three crop subplots. The following eight mulch treatments were evaluated: Bare soil (no mulch), Planter’s Paper (Paris Farmers Union, Oxford, ME), WeedGuard (Sunshine Paper Co., Aurora, CO), black paper mulch (Verso Paper Corporation, Bucksport, ME) and three degradable plastic mulches. The CP series are paper mulches developed at the University of Maine and produced by Monadnock Paper Mills, Inc. (Bennington, NH). Application of the CP paper mulch was straightforward and uncomplicated with only minor adjustments needed to the mulch layer. The roll was placed in the roller cradle closest to the tractor and the roller tension set as loose as possible. The tension wheels were held off the mulch by tying them up to the mulch layer frame. The Planter’s paper and WeedGuard papers could only be applied by hand. The plastic mulch showed no signs of degradation through the growing season. The degradable plastic mulch had slight degradation by the end of the growing season. CP588 showed only slight degradation through the growing season. The Verso Planter’s paper and WeedGuard paper mulches had rapid degradation of the buried portion soon after application. On 7 Aug., winds tore large sections of CP577, WeedGuard, Planter’s paper and CP581 mulches. The overall performance of the paper mulches was very promising. The paper mulches produced yields in this experiment similar to both standard plastic mulch and degradable plastic mulch.

An asterisk (*) following a name indicates the presenting author.

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The experimental CP paper mulches are superior to the commercially available papers in that they are able to be applied using standard agricultural mulch laying equipment. Of the papers tested CP 588 was considered superior. The paper remained intact through the entire season and produce yields of the three crops evaluated comparable to the standard production practice of black plastic mulch.

**Tomato and Zucchini Squash Yields Are Increased in No-till Compared to Conventional Tillage Plots** *(Poster Board #033)*

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No-till production systems are gaining attention as a practical way to produce vegetables sustainably and improve soil quality. Growing and managing cover crops to provide ground cover mulches is an important component of these production systems. The combination of cover crop mulches on the surface, and reduced tillage practices can have numerous benefits to soil health and vegetable quality, while positively impacting yields. Non-chemical methods, such as strip tillage, mowing, and rolling and crimping, of cover crop termination to provide a killed cover crop mulch for a no-till production system can be used with great success. Thus, the objective of this research project was to determine the benefits of no-till production system on summer squash and tomato yield and quality. Cover crops were established in Sept. 2016. Cover crop plots consisted of cereal rye, hairy vetch, a combination of cereal rye and hairy vetch, and a no cover crop control. Cereal rye was seeded at 150 lb/acre, hairy vetch at 120 lb/ac, and the combination of at 75 and 60 lb/acre, respectively. Plots were 12 × 50 ft and were fertilized with 60 lb/acre of composted chicken litter. Cover crop biomass and weed population data were taken just before termination. Weed populations were taken every two weeks throughout the growing season. In Apr. 2017, the cover crops were terminated with a roller-crimper. Seeds of “Skyway” tomato were sown into Pro-Mix BX soilless medium and germinated in greenhouse conditions at 25/20 °C (day/night). Zucchini squash ‘Yellow Fin’ were direct seeded into the killed cover crop plots. Tomato plants were transplanted with a modified no-till vegetable transplanter. Plants of tomato and zucchini were arranged in randomized complete block design with four replications. Tomato and Zucchini fruit were harvested and graded by size according to USDA standards. Results indicated that the cereal rye and the combination of cereal rye and hairy vetch cover crop plots had significantly lower weed densities. Cereal rye also had a positive impact on total tomato and zucchini fruit number and weight when compared to the control treatment. Cereal rye and the combination of cereal rye and vetch the number of large and extra-large tomato fruit and weight. Additionally, all cover crops had a significant increase in medium zucchini fruit and weight when compared to the control treatment. Overall, tomato and zucchini fruit yields were positively impacted by a no-till cover crop production system.

**Specified Source(s) of Funding:** This study was a contribution of the Mississippi Agriculture and Forestry Experiment Station and USDA-NIFA Hatch S294 project MIS 146030

**Tolerance to Over the Top Applications of Halosulfuron on Tabasco Pepper** *(Poster Board #034)*

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Purple nutsedge (Cyperus rotundus L.) is a significant weed of Tabasco peppers grown on plastic mulch in Avery Island, Louisiana. Because nutsedge pierces plastic mulch, it competes directly with the crop. This presents a difficult pest control problem for producers, as there is no effective sedge control herbicide labeled for over the top application in Tabasco peppers. Due to its effectiveness at controlling many sedge species, halosulfuron is commonly used to control purple nutsedge in other vegetable crops. Halosulfuron was applied over the pepper plants at rates of 0.25, 0.50, and 1.00 oz/acre, with 0.25% (by volume) non-ionic surfactant using a CO2 backpack sprayer delivering 18 GPA. Tabasco pepper yield was not reduced by the halosulfuron rates evaluated in the study.

**Integrating Weed and Nutrient Management in Vegetable Crops with Corn Gluten Meal and Soybean Meal** *(Poster Board #035)*

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Bioprocessing byproducts, including corn gluten meal (CGM) and soybean meal (SM), are often used as organic fertilizers and also have demonstrated herbicidal potential. Using these products to integrate weed and nutrient management may increase the profitability of vegetable farms by reducing labor required to control weeds and apply fertilizer. Our research objective was to determine the effects of different bio-based products and application rates on weed suppression, mineral soil nitrogen (N), and crop yield in tomato (Solanum lycopersicum ‘Defiant’) and broccoli (Brassica oleracea var. italic a ‘Arcadia’).
Four rates of CGM and SM were applied to each of 10 plants in a 15 ft linear bed to achieve 0.5 g, 1 g, 2 g, and 5 g N/plant. These treatments were compared to weedy, weed-free and synthetic fertilizer controls. Velveteaf (Abutilon theophrasti) was seeded into each planting hole prior to treatment application, and emergence recorded weekly. Soil N was measured continuously for 4-8 weeks after treatment application with ion-exchange resin membranes. Tomato fruit and broccoli heads were removed at harvest maturity and weighed. Weed emergence was reduced up to 60% and 75% with the highest rates of SM and CGM, respectively. Soil N increased with amendment rate and spikes in ammonium may have contributed to weed suppression; however, amendment type and rate did not influence crop yield. A minimum of 180 g of CGM/ft² was required to achieve consistent weed suppression, which is 4.5 to 9 times greater than current industry recommendations (20-40 g/ft²).

Specified Source(s) of Funding: USDA AMS Specialty Crop Block Grant Program

Sustained Fruit Load Development in Greenhouse Bell Peppers (Poster Board #036)

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Bell pepper selections suited specifically well for intense management in greenhouse environments are now available. For optimal crop management and use of space, these peppers are usually trellised in vertical growing systems. A practice of one to four primary stems with pruned side shoots is often used to encourage reproductive growth and enhance productivity. Some cultivars have a tendency to produce a large number of fruits followed by periods of limited pepper development. To balance the fruit load over the season, selective removal of flowers has been suggested. The greenhouse bell pepper cultivars Felicitas (red), Sympathy (orange), and Bentley (yellow) were included to evaluate reducing the flower number for more consistent fruit development and harvest. Seeds were sown on 8 Feb. and the study conducted from 17 Mar. through 11 Sept. The plants were grown in a high-wire drip irrigation system using dutch (bato) buckets (17.7 L volume) filled with a 50/50 mixture of perlite and a peat-lite medium (Pro-Mix BX). The plants were trellised using two primary shoots off the main stem in a “V” shaped system. The lateral side-stems developing on the two primary stems were trimmed over three leaves throughout the study. In treatments with flower removal, every third flower was removed to allow no more than two sequential nodes on a stem to develop fruits. The pepper fruits were harvested mature with at least 90 percent color formation. Plants with no flower removal produced slightly higher yields over the 16 weeks of harvest. The total yield per plant was 4.2 ± 0.99 kg for ‘Felicitas’, 3.7 ± 0.51 kg for ‘Sympathy’ and 4.1 ± 0.75 kg for ‘Bentley’. Although there were small variations in overall yield, the size of individual peppers was not affected by the flower management. Subsequently, additional pepper fruits developed for harvest on intact plants. The number of harvested peppers per plant averaged 20 ± 3.7 (‘Felicitas’), 18 ± 2.8 (‘Sympathy’), and 17 ± 2.3 (‘Bentley’). Flower removal reduced the number of harvested fruits on a plant with 2 for ‘Bentley’ or 3 for ‘Felicitas’ and ‘Symphony’. The average weight of individual fruits was 217 ± 18.7 grams for ‘Felicitas’, 199 ± 13.8 for ‘Sympathy’ and 242 ± 11.6 grams for ‘Bentley’. Removing flowers to balance the fruit load over the season resulted in less variation in individual fruit size and more uniform pepper development and harvest.

Liqui-Plex® Increased Hot Pepper Yield and Plant Size in Soil Amended with Soil-Set® Formulation (Poster Board #037)

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Hot pepper intake in the U.S. has increased during the last decade due to increased interest in indigenous food. The impact of Soil-Set® (a soil amendment that contains natural enzymatic compounds and balanced nutrients), Grain-Set® (a foliar fertilizer that supplies Mn, S, and Zn to growing plants), and Liqui-Plex® Bonder WP (a foliar fertilizer that comprises minerals complexed with amino acids) on pepper, Capsicum annuum var. Georgia Flame yield, fruit and plant quality characteristics, and soil enzymes (urease and invertase) activity were investigated. A randomized complete-block design (RCBD) experiment was conducted at Kentucky State University Research Farm. Four treatments (Soil-Set, Grain-Set, Liqui-Plex, and a control) were replicated four times. Pepper seedlings of 52-days old were planted and drip-irrigated as needed. Mature red fruits were collected at three harvests, weighted, counted, and their quality characteristics (length, width, and wall-thickness) and antioxidants (vitamin C, β-carotene, total phenols), and soluble sugars content were determined. In harvest 1, results revealed that the plants treated with Soil-Set and Grain-Set formulations during the growing season produced the greatest fruit length (12.2 cm), whereas plants treated with Liqui-Plex formulation produced the greatest yield and greatest number of ripe fruits compared to the other treatments. Overall three harvests, results revealed that Liqui-Plex produced the greatest yield, greatest number of ripe fruits, and highest fruit wall thickness. These results could recommended to promote the use of Soil-Set and Liqui-Plex new formulations in growing pepper and other vegetables in the United States.

Specified Source(s) of Funding: USDA/NIFA Funds
Viticulture and Small Fruits 2 (Poster)

Fruiting Characteristics of Three Primocane-fruiting Blackberry Selections at Kentucky State University (Poster Board #402)
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Kentucky’s climate is well-suited for blackberry production. Two cane types exist within brambles: primocanes (or first-year canes), which are usually vegetative, but in primocane-fruiting cultivars will flower and fruit from late summer until frost, depending on temperature, plant health, and the location in which they are grown; and floricanes, which are the same canes, flowering and producing fruit the next growing season in mid summer. A primocane-bearing blackberry trial was planted at the Kentucky State University Research and Demonstration Farm. The planting contained the selections ‘Prime-Ark® Traveler’, ‘Stark® Black Gem®’, and APF-268, which are all primocane fruiting selections from the University of Arkansas. The objective of this study was to determine if ‘Stark® Black Gem®’ (APF-205T) and the advanced selection APF-268 is superior to ‘Prime-Ark® Traveler’ in terms of yield and fruit quality under Kentucky growing conditions. In 2017, no significant differences were found among the three selections in berry size for the floricane crop. APF-268 had significantly greater yield than the other two selections; ‘Prime-Ark® Traveler’ showed a trend to have a higher yield than ‘Stark® Black Gem®’. Primocane fruit size varied significantly; ‘Stark® Black Gem®’ and APF-268 had a larger fruit size than ‘Prime-Ark® Traveler’. APF-268 had significantly higher primocane yield whereas ‘Prime-Ark® Traveler’ had the lowest yield and ‘Stark® Black Gem®’ was between the two. Year-to-year yield characteristics will need to be further evaluated; however, the first-year data suggests that ‘Stark® Black Gem®’ has large fruit and yields well in Kentucky, and should be considered by growers interested in producing primocane fruiting blackberries for markets with little shipping.

Impacts of Border Vegetation on Multifunctional Biodiversity and Crop Production in Washington Blueberry (Poster Board #403)
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Herbaceous flowering or woody plant borders adjacent to highbush blueberry (Vaccinium corymbosum) fields have the potential to benefit both native pollinators and predatory insects and birds that feed on key blueberry pests, such as spotted wing drosophila (Drosophila suzukii; SWD). However, they may also draw pollinators away from the crop, serve as overwintering and/or refugia sites for SWD, and increase populations of wild birds that feed on fruit and transmit foodborne pathogens. The objective of this project was to explore the effects of border vegetation adjacent to blueberry fields on multifunctional biodiversity. In 2017 we measured pollination services, populations of beneficial and pest insect and bird species, and production attributes of blueberry grown with or without adjacent border vegetation on 9 commercial farms in northwest Washington. Our border vegetation treatments include: 1) Control (primarily medium-height grasses); 2) Woody perennial vegetation [mixture of woody species including Cedar (Cedrus sp.) and Arborvitae (Thuja sp.)]; and 3) Herbaceous vegetation [mixture of monocots (e.g., Poa sp. and quackgrass (Elymus sp)) and broadleaves (e.g., Taraxacum officinale)]. There were no differences in pollinator abundance, pollinator visitation rates, estimated yield, and fruit quality across the treatments. Pest and beneficial insects were collected during a 16-week period using an insect vacuum and apple cider vinegar traps. All treatments exhibited similar pest:beneficial ratios, but arthropod numbers varied widely between treatments. Herbaceous borders represented nearly 50% of the total arthropods collected, while the control exhibited over twice that of perennial borders. Spotted wing drosophila were absent in all localities. Sticky card data used to monitor arthropod movement between blueberry fields and their borders suggested there were no differences in field populations by treatment. However, there were overall greater populations of both pest and beneficial insects in the border vegetation relative to in the blueberry field. Point count surveys conducted in hedges and blueberry fields were used to evaluate the effects of border vegetation on wild bird populations. Pest species were observed in all habitats, but treatment trends suggest greater density of some species in some habitats. Preliminary data from this project show that while arthropod numbers vary among different borders, blueberry fields remain low in insect biodiversity, which is likely influenced by weekly SWD insecticide applications. Our evaluated border treatments have small to negligible impacts on our measured variables and no clear multifunctional benefits associated with our different border vegetation treatments were detected.

Specified Source(s) of Funding: WSU BIOAg
A modified over-the-row (OTR) harvester (Oxbo Model 7240) with experimental-catch surfaces was used for harvesting ‘Duke’ and ‘Draper’ blueberry in Oregon and ‘Elliott’ and ‘Aurora’ blueberry in NW Washington. All plants were hand-harvested once and then machine harvested (MH) about 7 days later. The modifications to the harvester included a soft intermediate surface over the plastic conveyor belt and hollowed out plastic catch plates (e.g. tennis racket head) to which neoprene sheet (SCS) installed on one side and on the other side a canvass like intermediate surface over the conveyor belt and standard plastic catch plates (HCS). In Oregon, handheld pneumatic shakers operated by workers standing on a platform and in Washington a totally mechanical Orbirotor picking system were used. Harvested fruits were run through commercial packing lines with fresh pack-out recorded and fresh fruit quality evaluated during various length of cold storage. The fresh pack-out for ‘Draper’ and ‘Duke’ were at 73% and 83%, respectively, and no difference was noted between MH with SCS and HCS. ‘Draper’ and ‘Elliott’ fruit firmness was the highest with hand harvesting, followed by MH with SCS and HCS which had the same firmness. Hand-harvested ‘Aurora’ had the same fruit firmness as MH with SCS. After 2–4 weeks cold storage, fruit firmness for both ‘Draper’ and ‘Duke’ decreased in MH fruits. For ‘Elliott’ and ‘Aurora’, fruit firmness was the same among harvesting methods after 2 weeks of cold storage. ‘Aurora’ fruit had similar bruise ratings between hand harvesting and MH with SCS, while ‘Elliott’ fruit showed more bruise damage by MH with both SCS and HCS than in hand harvested fruit. Postharvest bruise ratings of ‘Elliott’ fruit were not affected by harvesting method, while the bruise ratings of ‘Aurora’ was lower in hand harvested fruits compared to MH with both SCS and HCS. Although our studies showed slightly lower fresh market blueberry pack-outs (%), increased bruise damage, and loss of firmness in fruit harvested by the experimental MH system compared to the hand harvested fruit, these findings were much better than those achieved by commercial OTR harvesters. We demonstrated that fresh market blueberry quality is achievable by using an OTR harvester with softer fruit catching surfaces.

**Soil Moisture Variability and Management in a Cranberry Bog** *(Poster Board #405)*

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Summer irrigation is a major management input in cranberry production, and traditionally, cranberry beds have received 25 mm of water per week from either rain, capillary action from groundwater, irrigation, or some combination of these from late spring through the summer. However, environmental conditions and drainage characteristics can vary from bog to bog, meaning that the 25-mm rule does not always result in ideal soil moisture conditions. Measurement of cranberry soil water status has been based on two technologies: (i) measuring the amount of water in the soil using volumetric water sensors or measuring the depth of the water table in the soil by means of water level floats; and (ii) measuring the energy status of the water (water potential) using a tensiometer. Ideally, irrigation scheduling should consider plant processes in conjunction with the status of the soil water matrix to quantify water stress under different soil conditions. This project assessed various tools of measuring soil water moisture in cranberry beds including a FieldScout TDR 300 Soil Moisture Meter and wireless tensiometers. Six cranberry beds primarily growing cultivar ‘Stevens’ were monitored throughout the growing season for tension readings; wireless tensiometers reported data to a web portal at 15-minute intervals, making it easy to download data. The FieldScout TDR 300 Soil Moisture Meter was used to develop soil moisture maps of monitored beds on a weekly basis during the season. The Moisture Meter was connected to a GIS unit so that generated maps could be overlaid on a satellite image of the bed providing precise locations of soil moisture content at the time of measurement. The FieldScout TDR 300 Soil Moisture Meter maps indicated a great variability in soil moisture throughout monitored cranberry beds. Soil moisture variability demonstrated a 10 to 20% range of differences. This lack of uniformity in soil moisture content makes it difficult to choose an ideal location for installing a soil moisture monitoring device such as a tensiometer.

**Performance of Aronia Mitschurinii ‘Viking’ Grafted Onto Pyrinae Tree Rootstocks.** *(Poster Board #406)*

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*Aronia* is a novel fruit crop that produces black fruits that are one of the richest sources of dietary polyphenols and anthocyanins. *Aronia* grows as a multistemmed shrub with many basal shoots. Aronia berries are machine harvested commercially, but low branches laden with fruit are missed by harvesters resulting in 20 to 30% loss of harvest. The low branching also makes weed management difficult. We studied the compatibility and perfor-
mance of *Aronia mitschurinii* ‘Viking’ grafted onto various tree rootstocks in the Pyrinae including *Crataegus laevigata, Pyrus communis, Sorbus aihnifolia* and *Sorbus aucuparia* in comparison to own-root cutting plants. Chip bud grafting was used and scions were grafted at 15 cm and also at 60 cm for *Sorbus aucuparia*. Best grafting success occurred with *S. aucuparia* at over 85%, while *Crataegus* had the lowest success rate at 33%. Success with *Pyrus* and *S. aihnifolia* was ~50%. Significant losses of grafts on *Pyrus* and *Crataegus* occurred in the second and third growing seasons, while no losses occurred with *Sorbus* rootstocks. Plants grafted onto *S. aucuparia* were larger and produced more shoot growth than any other rootstock species or own-root plants. Plants grafted onto *Sorbus* rootstocks yielded substantially more fruit than own-root plants or plants with *Crataegus* or *Pyrus* rootstocks. *S. aucuparia* produced about three times as much fruit as own-root plants and produced substantial yields at an earlier age than own-root plants. Mineral nutrient content of foliage and fruits were analyzed but did not show biologically significant differences between different rootstocks and own root plants. Some statistical differences were seen for fruit Brix and titratable acidity between study plants, but the differences are not significant as far as fruit quality is concerned. *A. mitschurinii* ‘Viking’ grafted at 60 cm high produced plants with architecture where all branches were held erect and well above the ground. These high grafted plants would allow mechanical harvesters to completely pick all fruit from the plants. Weed control, either by mechanical or herbicide applications, would be easy with the high grafted plants. *Crataegus* and *Pyrus* are not suitable species for use as rootstocks with *Aronia*. *Sorbus*, especially *S. aucuparia*, is an ideal rootstock for use with *Aronia*.

**Diversity of Fruit Quality Traits in Aronia**

*(Poster Board #407)*

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The genus *Aronia* is a group of deciduous shrubs in the Rosaceae family, subtribe Pyrinae and are native to eastern regions in North America. The four commonly accepted species include *A. arbutifolia* (L.) Pers., red chokeberry; *A. melanocarpa* (Michx.) Elliott, black chokeberry; *A. prunifolia* (Marshall) Reheder, purple chokeberry; and *A. mitschurinii* (A.K. Skvortsov & Maitul), involving *A. melanocarpa* × *Sorbus aucuparia* hybridization. The sugar content of *Aronia* fruit is one of the primary traits perceived by consumers. The development of new *Aronia* cultivars with sugar-enhanced content is a primary objective of our breeding program. The *Aronia* germplasm collection at the University of Connecticut, comprised of 120 wild and domesticated accessions, was evaluated for fruit physical traits (weight, size, and percent water content) and fruit chemical traits [total soluble solids (brix) and titratable acidity (TA)] at peak ripe development. A subset of accessions representing six taxonomic groups [six *A. melanocarpa* (2x), two *A. melanocarpa* (4x), two *A. melanocarpa*-S (4x), one *A. prunifolia* (3x), two *A. prunifolia* (4x), and two *A. arbutifolia* (4x)] were evaluated at three stages of fruit development. There was a significant amount of variability for physical and chemical traits within and between each taxonomic group at stage two (peak ripe). In general, fruit size, water content and brix increased at each developmental stage. There was a significant negative correlation between water content and brix values. Brix:TA ratios of *A. melanocarpa*-S accessions were significantly higher than all other *Aronia* species. *A. mitschurinii* had the lowest brix:TA ratios, suggesting that wild *Aronia* species may be useful in a breeding program to improve flavor of *Aronia* fruits for commercial production and fresh consumption. The results from this study will provide useful information on future breeding efforts of *Aronia* for commercial fruit production.

**Texas Pomegranate Variety Trial: Differences in Yield and Fruit Quality** *(Poster Board #408)*

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an antioxidant from fruits of 7-year-old trees) were determined. Fruit yield harvested in 2017 (2-year-old orchard) indicated that ‘Salavatski’ had the highest yield of 7.96 kg per tree, while ‘Early Wonderful’, ‘Kandahar’, ‘Mollar’, and ‘Angel Red’ had the lowest yield with 0.99–2.54 kg fruits per tree. The top five cultivars with the highest percentage of fruit sunburn were ‘Angel Red’, ‘Surhanor’, ‘Russian 8’, ‘Kandahar’, and ‘Salavatski’, the top five for the highest percentages of fruit split were ‘Angel Red’, ‘ML’, ‘Early Wonderful’, ‘Ben Ivey’, and ‘Larry Ceballos 1’. To compare the differences in fruit phenolic compounds and antioxidant capacity, fruit samples were collected from a seven-year-old mature orchard. The top five cultivars with high phenolic contents and antioxidant capacity were ‘Early Wonderful’, ‘DeAnda’, ‘Wonderful’, ‘Larry Ceballos 1’, and ‘Purple Heart’ and top five for Brix were ‘Early Wonderful’, ‘DeAnda’, ‘Ben Ivey’, ‘Salvatski’, and ‘Wonderful’. In summary, ‘DeAnda’, ‘Early Wonderful’, and ‘Wonderful’ are among the top cultivars regarding fruit phytonutrient contents.

*Specified Source(s) of Funding:* Specialty crop block grant

**Fruit Breeding (Poster)**

**What Resonates with Our Stakeholders? The Impact of Rosbreed As Communicated by Trade Magazine Writers (Poster Board #055)**

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RosBREED, a large-scale research and development project funded since 2009 by USDA-SCRI, is a collaborative effort across multiple states and institutions focused on improving U.S. rosaceous crops through DNA-informed breeding. The end goal is new cultivars that meet industry standards for horticultural quality and disease resistance and exceed consumer expectations for attributes like flavor, aroma, and texture. A critical outcome is to increase awareness of and support for DNA-informed breeding for rosaceous crops through regular engagement with stakeholders. A comprehensive, non-technical report provides a vehicle to share progress and obtain feedback at our annual advisory panel meeting. RosBREED’s strategic approach is to highlight outputs as success stories at such meetings, in individual interactions with clientele, in the project newsletter emailed to stakeholders three times a year, and as one-page “RosBRIEFs.” In addition to these stories of how DNA information is obtained and applied to meet the goals of plant breeding programs and their beneficiaries, the newsletter and RosBRIEFs include regular profiles of RosBREED team members and advisory panel members, features on the “disease nemeses” that RosBREED is targeting to develop durably resistant cultivars and breeding populations, and information about new cultivars being released by RosBREED-affiliated breeding programs. To more effectively communicate a technical deliverable like the discovery of large-effect loci for traits of value and the use of DNA information about the locus in parent and seedling selection, we developed the “Jewels in the Genome” analogy. A concise, color-coded DNA test table was then developed to illustrate to our industry clientele the progress toward “jewel” discovery and use in breeding programs, as well as track deliverables to breeders. References to these communication efforts in trade publications indicate that some success stories and communication tools are resonating with stakeholders. This study summarized and analyzed trade publication articles covering RosBREED in order to identify communication strategies that resonated with our stakeholders. The results suggest ways in which the project has communicated its outcomes and deliverables most effectively with clientele and where efforts should be focused to achieve widespread name-recognition of RosBREED and robust support for DNA-informed breeding in rosaceous crops.

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**Genetic Structure of the United States Rosbreed Sweet Cherry Germplasm Revealed by Genome-wide SNPs (Poster Board #056)**

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Sweet cherry (*Prunus avium* L.) is a clonally propagated, diploid, outcrossing crop for which cultivar development uses a pedigree-based breeding approach. Although sweet cherry breeding has been conducted in the Pacific Northwest for more than half a century, genetic structure of this sweet cherry germplasm is not well understood based on incomplete pedigree records. In this study, a pedigree population of 65 elite and wild sweet cherry clones and 463 unselected offspring from 86 crosses in the Washington State University sweet cherry breeding program, comprising a germplasm set established to be representative of U.S. public breeding germplasm for this crop, was genotyped with the RosBREED Illumina Infinium® 6K cherry SNP array.
Variation in Floral Bud Development between Early and Late Blooming Tart Cherries
(Poster Board #057)
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Flowering success directly translates to yield potential in perennial fruit trees such as cherry. Thus, erratic weather events that affect flowering can have a deleterious effect on crop yield. For instance, in 2012 Michigan tart cherry growers lost 97% of their crop after sporadic freezing temperatures in April killed most floral buds. Events like these can have long-lasting negative economic impacts on the tree fruit industry. And, as global climate change intensifies, unpredictable weather events are becoming more frequent. Two potential ways to reduce the risk of crop loss from frost damage include: 1) Breeding trees that bloom later in the season, and 2) identifying the point in development when flower buds are most susceptible to frost damage. This second strategy would enable growers to employ cultural practices to increase temperatures in their orchards if needed. The development of both mitigation methods would benefit from a greater understanding of the biology behind the regulation of bloom time. As a first step in this direction, we tracked developmental changes that occurred in dormant flower buds from naturally early and late blooming tart cherry trees as they accumulated heat units. Differences in morphology as well as pollen development between the genotypes were evident.

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Quantifying Variation in Warm Growing Degree Hour and Base Temperature for Floral Bud Break in Peach (Poster Board #059)
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Bud break timing in peach [Prunus persica (L.) Batsch] is determined by the fulfillment of a chilling requirement (CR) and a heat requirement (HR) for development. Genotypic variation in CR has been well-characterized in peach. Potential variation in HR among varieties has received less attention, in part due to the overlap of effective temperatures for CR and HR and dynamic modification of HR by continued chilling accumulation beyond the minimum threshold CR for bud break. HR could vary in the magnitude of growing degree hours (GDH) and/or the base temperature for accumulating GDH. We estimated the GDH and base temperature for floral bud break by forcing replicate stem cuttings at constant temperatures of 12, 14, 16, 18, and 20 °C and analyzing the effect of temperature on the inverse of hours accumulated to reach median bud break (defined by appearance of sepal or petal coloration). We evaluated >40 varieties (representing a range of CR) in which chilling had been saturated after 1800 h at 3 °C. Varieties differed in both GDH requirement and apparent base temperature for GDH accumulation. Phenotyping the separate components of HR without the confounding effect of unsaturated chilling was possible. This will allow standardized HR phenotyping in germplasm as a foundation for breeding delayed bloom and frost exposure avoidance. One variety was evaluated through a range of partial to fully satisfied chilling accumulations. Chilling accumulation reduced GDH while also altering base temperature for GDH accumulation. Improved descriptions of variety specific dynamics of GDH and base temperature response to chilling may allow improved bloom date modeling in peach.

Specified Source(s) of Funding: USDA-AMS-TM-Specialty Crop Block Grant Program, South Carolina Department of Agriculture

QTL Mapping with Pedigree-based Analysis for Blush, Soluble Solid Content, and Titratable Acidity in Peaches (Poster Board #060)
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The regulation of bloom time. As a first step in this direction, we tracked developmental changes that occurred in dormant flower buds from naturally early and late blooming tart cherry trees as they accumulated heat units. Differences in morphology as well as pollen development between the genotypes were evident.
Expression of Some Specific Cell Genes Reveals Key Facilitators of Cell Production during Development of Apples (Poster Board #062)
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Cell production is an important factor to affect fruit size during fruit development. Fruit development can fall apart into three parts: flower-tube growth, fruit set and fruit growth. All of them are regulated by genes expression. In this project, the aim is to test the effect of some specific genes expression on cell production, and then how them influence apples size. At the end, a connection of specific genes expression, cell production and apple size will be made by this research. In this research, two varieties of apples trees, Gala and Golden Delicious Smoothee, will be selected. These two varieties of trees can produce different size of apples. Two kinds of data should be collected, phenotype and genotype. Phenotype includes apple diameter, length, weight, cell number, relative cell production rate. Genotype includes specific genes expression. All of these data will be collected every week from flower-tube growth to fruit growth. After that, based on statistics analysis, a dynamic variation rule will be detected with the time development. For example, Cell production will be inhibited by specific genes expression during floral-tube development, resulting in growth arrest before bloom. At the end, a connection between phenotype and genotype will be found.

Poster Presentations

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Fruit quality traits have significant effect on consumer acceptance and subsequently on the consumption of peach (Prunus persica L. Batsch). The improvement of quality traits such as sweetness, flavor, and texture can be enhanced throughout QTL discovery and validation to enable the use of marker assisted breeding (MAB). A Bayesian QTL mapping approach implemented in FlexQTL™ software has been conducted on seven F₁ low to medium chill families along with the founders and parents. Phenotypic data were collected for two years at a high chill (Clovis, CA) and a medium chill (College Station, TX) location (Clovis) and genotyped using the 9K SNP Illumina array. The objective of this study was to discover and/or validate the number and positions of quantitative trait loci (QTL) for quality traits: titratable acidity (TA), soluble solid content (SSC), and fruit skin blush (Blsh). Fourteen QTLs were identified for the three traits across the environments: eight QTLs with strong and decisive evidence and the other six QTLs with positive evidence. Several QTLs were reported in previous studies and a few were novel QTLs. QTLs for SSC in TX 2012 and TA in TX 2013 were not mapped because of lack of phenotypic data. The proportion of phenotypic variance explained (PVE) by a QTL for the three traits ranged from 18.9 to 94.8%. This approach would help to develop DNA marker test and subsequent marker-assisted breeding for developing new peach cultivars of superior quality traits.

QTL Mapping for Fruit Weight and Diameter through Pedigree-based Analysis in Peach
(Poster Board #061)
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Peach is one of the most important fruit crops in the world, with the global annual production exceeding 24.9 million tons. The United States is the fourth largest producer after China, Spain, and Italy. Peach consumption has decreased over the last decade, most likely due to inconsistent quality of the fruit in the market. Fruit weight (FW) and diameter (FD) are important traits for market success, since consumers tend to prefer homogeneous fruits of large size. Marker-assisted selection for FW and FD is at the top of the wish list for fresh market peach breeding programs and one of the major goals of the RosBREED project. The ability to use DNA information to select desirable fruit size would enable peach breeders to efficiently plan crosses and select seedlings with large FW and FD, early in the selection process before even seeing the fruit. Therefore, to understand genetic background of FW and FD in peach, we assembled pedigree connected breeding material of 620 individuals from three public fresh market peach breeding programs (Arkansas, Texas and South Carolina). The material was genotyped using 9K SNP array and FW and FD were phenotyped over two seasons. Pedigree based analysis (PBA) using both additive and dominance genetic effects identified seven QTLs on three chromosomes. Three QTLs were associated with FW on linkage groups (LG) 1 (qPP-FW_1.1), 4 (qPP-FW_4.1), and 6 (qPP-FW_6.1). Four QTLs were associated with FD; two on LG 1 (qPP-FD_1.1; qPP-FD_1.2), and one on each LG 4 (qPP-FD_4.1) and 6 (qPP-FD_6.1). The strong positive correlation between FW and FD was reflected in clustering of the QTL for the two traits on LG 4. Haploblock/haplotype analyses revealed 1-3 haploblocks per QTL region with 7-31 haplotypes per haploblock. The highest number of haploblocks was detected on LG 4 (qPP-FD_4.1) and the highest number of haplotypes within the haploblock were detected in QTL qPP-FD_4.1_Hap1. The validation and characterization of functional alleles for fruit weight and size and their predictive effects, frequency, and distribution in the U.S. peach breeding germplasm will be presented.

Specified Source(s) of Funding: USDA-NIFA-SCRI “RosBREED: Combining disease resistance with horticultural quality in new rosaceous cultivars” (2014-51181-22378)
and these specific genes function would also be detected. In the next project, all genes which can control cell production would be tested by QTL analysis and then the secret of co-expression of genes will be found in this project.

**Development of High-Throughput SNP Markers for Fruity Aroma and Marker-assisted Selection in Cultivated Strawberry (Fragaria ×ananassa)**

(Poster Board #063)

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Fruit flavor is one of the most important traits for strawberry breeding. In our previous study, γ-decalactone regulated by FaFAD1 gene, contributes to fresh peach flavor and is associated with an increase in sweetness in fruit. The dominant FaFAD1 marker developed from the FaFAD1 gene is currently used for the high-throughput marker-assisted seedling selection (MASS) for γ-decalactone. However, the main limitation in using dominant marker is not possible to differentiate homozygosity and heterozygosity. Also because of the unique amplification of the target fragment, failures in polymerase chain reaction (PCR) or non-amplifications can be interpreted as an absence of the allele. Thus, an internal amplification control has to be carried out to determine the success of PCR. This is a bottleneck for high-throughput MASS with large breeding samples. Therefore, in this study, codominant single-nucleotide polymorphism (SNP) markers for FaFAD1 were developed for the effectiveness of MASS. To identify SNPs associated with FaFAD1, the 100kb genomic region of FaFAD1 was sequenced with GD producing and nonproducing accessions: 10 producer (FL10-24, ‘Sweet Charlie’, ‘Albion’, FL11.28-34, Florida 127, ‘Winterstar’, FL12.115-10, ‘Elyana’, ‘Benicia’, and FL11.139-10) and five non-producer (‘Festival’, ‘Winter Dawn’, ‘Mara des Bois’, FL13.55.195, and FL12.74-39). Four unique SNPs that can differentiate GD producers and non-producers were identified and used to develop for high-resolution melting (HRM) markers. Two HRM markers GD2-001 and GD4-001 successfully detect the presence and absence of GD in all accessions tested. We further tested these markers with crude extract DNA to examine the accuracy of the high-throughput MASS. Both markers accurately detected γ-decalactone producing accessions. The markers developed from the present study will be useful for strawberry breeding program for enhancing fruit quality.

_Specified Source(s) of Funding:_ “RosBREED: Combining disease resistance with horticultural quality in new rosaceous cultivars” under award number 2014-51181-22378

**Evaluation of Genetic Stability of F₁ Hybrids in Octoploid Strawberry** (Poster Board #064)

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The modern, cultivated strawberry is propagated vegetatively using stolons and crown as clones, but it is required the many labor and time for the propagation of the nursery plant, and become the cause of greatly reducing yield by viruses and pathogen infection. Therefore, seed propagation in strawberry plants has been in demand for a long time. The present study aimed to test genetic stability of F₁ hybrids strawberry through crosses between S9 generation plants of inbred lines derived from octoploid strawberry, because the stability and uniform phenotypes of F₁ hybrids strawberry have been confirmed in prior studies. Breeding of inbred lines (S9 generations) for seed propagation in octoploid strawberry could be achieved that individuals showing inbreeding depression were eliminated and vigorous individuals were selected, resulting in a strong heterosis of F₁ hybrids through crosses between inbred lines. Genetic stability of F₁ hybrids strawberry was tested using seven simple sequence repeat (SSR) markers. We detected high (>0.90) genetic similarity among individuals of F1 hybrids and individuals of S9 or S11 inbred lines derived from ‘Benihoppe’, ‘Toyonoka’, and ‘Akihime’, the original ovary and pollen parental cultivars. The genetic similarity among inbred lines increased with the advancement of selfing generations, and that of F₁ hybrids produced through hybridization between inbred lines was also very high. Although the genetic similarity among these individual inbred lines and F₁ hybrids was very high, some variation was detected, but it did not result in morphological differences. With the advancement of selfing generations, the yield and fruit weight tended to decrease in the F₁ hybrids. To develop commercially useful seed-propagated cultivars, the breeding techniques such as the effects of different cross combinations or crossing among and within selfing generations should be investigated.

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Construction of a Genetic Linkage Map of Octoploid Strawberry (*Fragaria xananassas*) Using HRM Markers Developed from the SNP Identified by Next-generation Resequencing of Parents (Poster Board #065)

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Strawberry is one of the most popular important berry fruits in the world and the cultivated strawberry (*Fragaria xananassas* Duch.) is allo-octoploid (2n = 8x = 56). There were few genomic studies of the octoploid strawberry due to polyploidy and complexity of its genome. In this study, we tried to construct a genetic linkage map of the octoploid strawberry using single nucleotide polymorphism (SNP) markers derived from next-generation resequencing (NGS) of two parents, which were ‘Sulhyang’ as a maternal parent and ‘Senga-sengana’ as a paternal parent. Their F1 segregating population consisting of 97 individuals was used to construct a genetic linkage map. A total of 19.0 Gbp (‘Sulhyang’) and 21.8 Gbp (‘Senga-sengana’) of genomic sequences, which were 30- and 26- times longer than the reference strawberry genome (the reference genome size = 720 Mbp), were obtained through NGS analysis. Subsequently, 215,461 SNPs were identified by comparing the sequences between two parents and 1857 primer sets for high-resolution melting (HRM) analysis were designed through bioinformatic analysis. Finally, a total of 835 polymorphic HRM markers were developed and 651 markers were mapped on the genetic linkage map of octoploid strawberry. The genetic linkage map contained 36 linkage groups, covered a total distance of 1379.1 cM. The information on the genetic map and markers will be helpful to analyze QTLs for important traits in octoploid strawberry.

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Mapping of Eastern Filbert Blight Resistance in ‘Estrella#1’ Hazelnut (Poster Board #066)

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Eastern filbert blight (EFB) caused by *Anisogramma anomala* was first discovered in Oregon’s Willamette Valley in 1986 and remains a costly concern of the United States hazelnut industry. Host resistance is the most effective method of disease control. A very high level of EFB resistance, discovered in ‘Gasaway’, is controlled by a dominant allele at a single locus. This resistance may not be durable, as new races of the fungus able to overcome this R-gene could be introduced or arise from mutation or recombination. The pyramiding of multiple resistance genes in a single genotype is a promising approach for more durable resistance. Segregation for EFB response was studied in seedlings from a controlled cross of resistant ‘Estrella#1’ and susceptible selection OSU 1174.033. Estrella#1 was released by private breeder Cecil Farris and is a hybrid of *C. heterophylla sutchuensis* × *C. avellana*. The seedlings were exposed to EFB spores under a structure topped with diseased branches as well as field exposure. Disease severity was rated 18–20 months after exposure on a scale of 0 (absence of disease) to 5 (severe disease symptoms). DNA of the seedlings was extracted and amplified with several microsatellite primer pairs, and correlation coefficients calculated between disease response and marker allele scores. ‘Estrella#1’ resistance was assigned to linkage group 6 (LG6) based on high correlation of disease response with marker scores at mapped LG6 microsatellite markers. A total of 14 markers on LG6 showed correlation coefficients > 0.7, and these map to the same region as ‘Gasaway’ resistance. A linkage map was constructed for the ‘Estrella#1’ resistance region and aligned with the ‘Gasaway’ resistance region. ‘Estrella#1’ provides a novel source of EFB resistance, for which linked markers will be useful for marker-assisted selection and the pyramiding of EFB resistance alleles from different sources.

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Comparison of Self- and Cross-pollination on Pollen Tube Growth and Ovule Development in Chinese Chestnut (*Castanea mollissima*) (Poster Board #067)

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Chinese chestnut (*Castanea mollissima* Blume) has noteworthy ecological, economic, and cultural importance in China. However, a high proportion of empty cupules is mainly responsible for low yield in chestnut. To elucidate the causes of the empty cupules, we investigated pollen germination and pollen tube growth into pistils, and ovule development after self-pollination (SP) and cross-pollination (CP). Controlled pollinations were carried out with chestnut trees cultivated on the qianxi county of Hebei province. Ten pistils for each treatment were sampled at different intervals (0, 3, 6, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, and 30 days) after pollination for observation of pollen tube growth into pistils and ovule development by microscopy. The results showed that there were no significant
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Genetics and Germplasm 2 (Poster)

Capture-Seq Based Blueberry Linkage Map Construction and QTL Identification
(Poster Board #278)

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Reduced representation sequencing approaches, such as genotyping-by-sequencing, have been widely applied in major crops such as maize and soybean and are now being used in horticultural crops like berries and fruit trees. As the original and largest producer of blueberry, the United States maintains the most diverse blueberry germplasm resources. We previously developed a diploid blueberry F₁ interspecific population for genetic linkage map construction by crossing the parent F₁ (#10 (Vaccinium darrowii F1a4B × Vaccinium corymbosum W85-20) with the parent W85-23 (Vaccinium corymbosum)). Employing a Capture-Seq technology developed by RAPiD Genomics, with emphasis on probe design in predicted gene regions, 117 F₁ progeny, two parents, and two grandparents of this population were sequenced, yielding 138.64 Gbp raw sequenced reads with a depth per locus of ~13.23x. A total of 143,313 raw SNPs referenced to 95% of publicly available blueberry genome scaffolds were called and filtered to arrive at an approximately 80k high quality SNP set. We then developed a parental-dependent sliding window approach to further genotype this population, deduced bin markers from sliding windows along each reference scaffold, and used the markers for linkage map construction. Twelve blueberry linkage groups were constructed using OneMap (an R package) resulting in the highest density map reported to date in blueberry. We also scored many horticulturally significant traits in this population including important fruit quality traits such as fruit color, firmness, flavor, and weight over multiple years. Correlation among these traits was calculated using Spearman’s rho function. An R/qtl package was used to associate these traits to our fine map and identify corresponding regions with high LOD scores. In summary, we report here the first Capture-Seq based blueberry linkage map of our diploid population with a saturated marker density. This map is being used to identify QTL for important traits and will facilitate ongoing efforts to develop a chromosome level blueberry genome assembly.

Differential Gene Expression of Southern Highbush Blueberry ‘O’Neal’ Floral Buds in Response to Freeze Treatment and Recovery Periods (Poster Board #279)

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Cold hardness and chill hour requirement in blueberries (Vaccinium corymbosum L.) are functions of germplasm composition. Southern highbush blueberries (SHB) are less cold tolerant than northern highbush blueberries and have a lower chill hour requirement, causing buds to deacclimate and break earlier. Deacclimation and bud swell heightens susceptibility to spring freezes, a recurring event in southeastern United States. The objective of this study was to determine the differentially expressed genes in floral buds prior to bud swell and post-bud break of SHB cv. O’Neal, selected for its unique flowering behavior. Flower buds at two stages, bud swell and tight cluster, were exposed to either non-freezing (4 °C) or freezing conditions (−12 °C) achieved through an environmental control chamber decreasing 4 °C/hour. Following temperature treatment, the buds recovered at 4 °C for periods of either one day or one week and were subsequently flash frozen in liquid nitrogen. A total of 24 stranded mRNA-Seq libraries (8 treatments × 3 biological...
Genetic Mapping of the Spine-free Locus in Red Raspberry Using Genotype-by-sequencing (GBS) (Poster Board #280)

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Red raspberry (Rubus idaeus L.) is a globally commercialized specialty crop. Field management of raspberry canes and harvesting of raspberry fruit can be complicated by the presence of spines or prickles (as is botanically more accurate) on the stems, petioles and underside of the leaves. Prickles are an outgrowth of epidermal tissues that lack vasculature. The development of new raspberry varieties with fewer or prickle-free canes will aid in both harvesting of the fruit and field management. A population segregating for the presence of prickles was used in this study to identify differentially expressed genes (DEGs) between tissue, temperature, and recovery periods. RNA-Seq analysis (log2 fold change >2; \( P \leq 0.05 \)) revealed that there were 1913 DEGs related to tissue, 3810 DEGs related to temperature, and 4440 DEGs related to recovery that were upregulated. With 4 °C as a reference, DEGs associated with −12 °C temperature treatment had more upregulated unigenes associated with tight cluster tissue type at either recovery treatment. Between tissue types, tight cluster universally had more upregulated unigenes considering both freezing treatments in conjunction with either recovery period. Unigenes corresponding to treatments of −12 °C, prior to bud swell, at one-day recovery had more uniquely expressed unigenes across the three treatments. Future work involves mapping and analyzing the assembly against the ‘O’Neal’ genome and its PacBio Iso-Seq data as well as gene network analysis. This research will provide the first data of its kind in genetic regulation of bud cold tolerance and recovery from spring freeze events, which establishes a molecular foundation for future molecular breeding projects.

Specified Source(s) of Funding: This research was funded by the North Carolina Blueberry Council, the North Carolina Department of Agriculture and Consumer Services, the North Carolina State University Agriculture Foundation, and the Southern Regional Small Fruit Consortium

Assessment of Leaf Chlorophyll Content under Salt Conditions in Cowpea Seedlings over Time (Poster Board #281)

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With poor quality of irrigation water, cultivated areas facing salinity keep increasing, hence preventing cowpea [Vigna unguiculata (L.)] from being cultivated in areas where its optimal growth and development conditions are found. However, to date, few salt-tolerant cowpea cultivars have been reported, which has resulted in a less performing cowpea breeding program for salt tolerance. Previous investigations showed that accumulations of Na⁺ and Cl⁻ in leaves resulted in reduction in chlorophyll content, thus affecting photosynthesis. Understanding how chlorophyll content evolves over time will assist plant breeders in selecting cowpea genotypes with better tolerance to salinity by choosing those with more stable chlorophyll content under salt stress. Therefore, the objective of this study was to evaluate the chlorophyll content of cowpea genotypes over 24 days of salt stress at seedling stage. A total of 30 cowpea accessions previously shown as having different responses were used in this study. Salt treatments were 0 mM and 200 mM NaCl. Experiment design was completely randomized (CRD) with three replications per genotype and salt treatment combination, and organized in a split-plot manner. Salt stress was imposed for 24 days. Results revealed that: 1) time × genotype interaction was significant in both salt conditions and without salt conditions; 2) chlorophyll content slowly decreased in the salt-tolerant genotypes; 3) chlorophyll content slightly increased at 6 and 9 days of salt stress in both moderate and sensitive genotypes, but decreased at a faster rate than in the salt-tolerant ones; and 4)
the salt sensitive genotypes were completely dead at 24 days of salt stress, whereas the salt-tolerant ones were able to maintain a significant amount of chlorophyll content at that time. These results can be used for advancing breeding programs for salt tolerance in cowpea.

**Identifying Phenotypes, Markers, and Genes in Carrot Germplasm to Deliver Improved Carrots to Growers and Consumers** *(Poster Board #282)*

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The feedback revealed that the carrot industry needs breeding stocks and genomic tools that can be used to develop carrots with improved field performance, including disease and pest resistance, and abiotic stress tolerance; and improved flavor and nutritional quality to better meet consumer needs. Given this critical stakeholder input, the goals of this project are to: 1) phenotype diverse carrot germplasm and breeding stocks to discover and characterize variation for traits important for improving carrots for the U.S. market; 2) develop an expanded carrot genomic and phenotypic database for breeders to catalogue genomic variation and track genes underlying important traits; 3) initiate the development of breeding pools from diverse germplasm and breeding stocks that include alleles for improved crop production and consumer quality traits, and test them on-farm with growers, including for flavor and nutritional value for consumers; and 4) assess the market value and impacts of carrot traits on grower and consumer decisions. A timeline of activities has been developed, with evaluation of approximately 750 modern and heirloom open-pollinated cultivars; landraces from the Middle East, Asia, Africa, Europe, and South America; and breeding lines from public sector carrot improvement programs initiated. To date, new sources of resistance to Alternaria leaf blight and root-knot nematodes, reduced incidence of bolting, and improved stand establishment, flavor, and nutritional quality have been identified preliminarily. The development of breeding pools has been initiated to capture enriched sources of allelic variation useful for carrot breeders, and an expanded carrot database that includes both genomic and phenotypic data is being created.

**Specified Source(s) of Funding:** USDA-NIFA-SCRI 2016-51181-25400

**Genetic Diversity in Sweetpotato (Ipomoea batatas) Germplasm in Japan Revealed By Genome Wide RAD-Seq** *(Poster Board #283)*

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Sweetpotato (Ipomoea batatas) is one of the most important root crops in the world, especially in Asian and African countries. It (called ‘satsuma-imo’) has been widely cultivated in Japan, and are utilized in many favorite dishes as well as industries. In Japan, sweetpotato breeding is conducted vigorously to improve the yield, components of storage root and tolerance to pest and...
Poster Presentations

Identification and Evaluation of White Rust Resistance in Spinach Germplasm
(Poster Board #284)

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White rust is an economically important disease of spinach (Spinacia oleracea) caused by Albugo occidentalis, which is epidemic in spinach production areas of the central and eastern United States. A total of 440 spinach genotypes including 400 USDA germplasm accessions and 40 Arkansas spinach breeding lines were evaluated for white rust resistance during the 2016–17 and 2017–18 winter seasons at the Del Monte White Rust Nursery in Crystal City, TX where heavy disease pressure has consistently been observed for 30 years. Each accession was naturally inoculated. Disease reactions of each accession were evaluated at the before bolting stage in the trial. Percentage leaf infection was assessed visually using a 0–9 scale (0 = no disease symptom, 1 ≤ 10%, 2 ≤ 20%, 3 ≤ 30%, 4 ≤ 40%, 5 ≤ 50%, 6 ≤ 60%, 7 ≤ 70%, 8 ≤ 80%, and 9 ≥ 90%). The results showed that ten accessions (CPPSIH 3 03, NSL 6098, PI 175311, PI 220686, PI 224959, PI 226671, PI 227045, PI 648958, PI 662302 and PI 677114) exhibited resistant to white rust (90% or more of leaf area are not got infected). By selection under heavy disease pressure, ten UARK breeding lines (08-03-316-1, 08-269-1, 08-275, 08-301-2, 08-321, 08-88-310, 08-198, 08-143-1, 08-103, 03-316-7) exhibit high resistant to white rust, their true leaves almost do not get infected and show symptoms. These resistant genotypes provide a valuable resource for functional gene exploration and as a source of white rust resistance for breeding programs.

Development of Genome-wide Simple Sequence Repeat Markers in Spinach (Poster Board #285)

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The decreasing costs of genome sequencing and the availability of well-assembled genome sequences for many crops has facilitated the identification and development of simple sequence repeats (SSR) markers. The genome sequence of inbred spinach line Sp75 (168X coverage) is publicly available. Genome sequences of six Sp75 chromosomes (463.4 Mb) were used to search for SSRs using the MISA program. The search criteria were set for the minimum number of repeats of 6, 5, 4, 4, 4 for di-, tri-, tetra-, penta-, and hexa-repeats respectively, and the maximal...
Phosphorus Bioavailability Adjustments of Insoluble Phosphates for Tomato By Adding Companion Ions or Chelates (Poster Board #286)

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Florida’s soils for vegetable production are rich in insoluble phosphates tied up with aluminum, calcium, iron, magnesium, etc. Mobilizing the insoluble phosphates is critical for crops such as tomato (Solanum lycopersicum) to use phosphorus (P) efficiently. The objective of this experiment is to expound the mechanisms of P bioavailability adjustment with three typical P-efficient and P-inefficient tomato genotypes—Great White Og, Japanese Black Trifele, Mariana F1 in hydroponics. Seedlings of the genotypes will hydroponically grow in modified Hoagland solution using tric-calcium phosphate (TCP) as the only P source with different concentrations of calcium or chelates such as EDTA until two sets of leaves fully expand. Chlorophyll content, pH, height, biomass, and concentration of N, P, and Ca will be determined. Our expected results will be: 1) ‘Great White Og’ and ‘Japanese Black Trifele’ will be more P-efficient than ‘Mariana F1’; 2) Extra calcium added to the culture solution will significantly downregulate P bioavailability of TCP; 3) ‘Great White Og’ and ‘Japanese Black Trifele’ can absorb more calcium than ‘Mariana F1’, and hence can mobilize more P from TCP; and 4) adding chelate to the solution will greatly upregulate P bioavailability of TCP. This means that calcium should not be applied with phosphate fertilizer on soil rich in calcium to enhance P use efficiency. As compared with ordinary genotype, elite genotypes may release more organic acids such as citric acid to the rhizosphere to mobilize the insoluble phosphates in soil.

Differential Gene Expression Profile between Resistant and Susceptible Tomato Genotypes in Response to Tomato-potato Psyllid (Bactericera cockerelli) Infestation (Poster Board #287)

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The tomato-potato psyllid (TPP), Bactericera cockerelli, vectors the phloem-limited bacteria Candidatus Liberibacter solanacearum (Lso), the causative agent of economically important plant diseases in Solanaceae species including the tomato vein-greening and potato zebra chip. The TPP has the ability to produce a three-pronged damage to its host plant. The TPP punctures the vascular bundles, secretes toxic saliva into the host, and vectors the disease-causing Lso bacterium. In response, the host plant deploys multiple layers of defense against the invading pest-pathogen complex. The objective of this study was to identify differentially expressed genes associated with host plant resistance reaction and to determine the role of Lso in the plant-insect interaction. Insect-resistant (Solanum habrochaites RIL) and susceptible (S. lycopersicum cv CastleMart) genotypes were mock-inoculated or infested with Lso positive TPP-Lso(+), negative TPP-Lso(-) insects. After 48-hrs, plant tissue was collected for RNAseq analysis. Differentially expressed genes (DEG, log2FC ≥ 2 and *P*-value ≤ 0.05) were identified between insect treatments and genotypes. Thirteen genes were uniquely up-regulated in the insect-resistant plants, but downregulated in susceptible plants when infested with Lso(-) psyllids. However, only one gene was up-regulated in resistant plants and down-regulated in susceptible plants when plants were infested with Lso(+). In the other hand, a total of 20 genes were uniquely down-regulated in resistant genotype while up-regulated in susceptible plants independently of Lso. Orthologues of these genes were mapped to determine putative molecular function and biological processes associated with plant defensive signaling. DEG included transcripts associated with catalytic activity (46%), binding activity (33%), transporter activity (12%), receptor activity (3%), antioxidant activity (2%), signal transducer activity (2%), and structural molecular activity (2%). Moreover, plant-defensive hormone salicylic acid (SA) is up-regulated in both resistant and susceptible plants when infested with TPP-Lso(+), but only in resistant plants when infested with TPP-Lso(-) insects. Taken together, these results suggest that different resistance and susceptibility factors are
involved in regulating plant responses to TPP. Furthermore, Lso may play an indirect role by either enhancing or eliciting additional plant resistance responses against the psyllid.

**Specified Source(s) of Funding:** Texas A&M AgriLife Vegetable Seed Grant

**Phylogenetic Patterns, Population Structure and Domestication Footprints in Broccoli and Other Brassica oleracea Vegetables (Poster Board #288)**

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Improvement efforts in Brassica oleracea vegetables such as broccoli (B. oleracea var. italica) are often limited by a lack of knowledge of the genetic diversity contained within available germplasm. Here, we employ genotype-by-sequencing on a diverse panel of (N = 134) B. oleracea entries including landrace and improved broccoli, landrace and improved cauliflower, kale, Chinese kale, Brussels sprouts, cabbage, collard, kohlrabi, and undomesticated B. oleracea relatives. We identified over 45K high-quality SNPs (mean = 91.0/Mbp or 45.5/haploblock) revealing a complex and admixed population structure. Vegetable groups were effectively resolved using principal coordinate analysis. When compared with a pool of landrace broccoli (N = 37), all improved broccoli entries (N = 26) released after 2000 were shown to be closely related, in higher linkage disequilibrium than landrace broccoli, and largely represented by a single subpopulation indicative of a genetic bottleneck occurring during modern cultivar development. Over 96% of SNPs differentiating improved cauliflower from landrace cauliflower were common to a larger pool of broccoli entries, supporting a “broccoli before cauliflower” domestication model via apparent introgression of broccoli alleles into improved cauliflower germplasm. Fixation index analysis identified several chromosomal regions differentiating improved broccoli and cauliflower entries. Of all the B. oleracea vegetable groups, kale and Brussels sprouts entries shared the greatest similarity with undomesticated B. oleracea wild relatives. Collard and cabbage entries shared high mutual similarity; supporting earlier work indicating cabbage as the primary collard progenitor. Chinese kale entries formed a monophyletic clade but share population structure components with Russian kale entries and the undomesticated B. insularis and B. macrocarpa.

**Specified Source(s) of Funding:** Specialty Crop Research Initiative grant no. 2016-51181-25402

**Identification and Molecular Mapping of Gummy Stem Blight (GSB) Resistance Gene in Wild Watermelon (Citrullus lanatus var. citroides) Germplasm PI 189225 (Poster Board #289)**

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Gummy stem blight, caused by Didymella bryoniae, is a destructive foliar disease of watermelon in areas with hot and humid climates. Wild watermelon germplasm, PI 189225 is a known source of resistance to gummy stem blight. The identification and the use of the molecular markers linked to resistance genes in the wild-type germplasm will speed up the introgression of the gummy stem blight resistance into new watermelon varieties. An F$_2$ segregating population was obtained from a cross between resistant wild watermelon genotype PI 189225 and susceptible genotype K3, after which genetic analysis of F$_2$, derived F$_3$ families was performed by inoculating plants with a single isolate of D. bryoniae (isolate 002, Jiangsu Academy of Agricultural Sciences). The results of genetic analysis demonstrated that gummy stem blight resistance in PI189225 was controlled by a major QTL, temporarily designated gsb-8.1. Based on the results of BSAseq, two associated regions spanning 0.27 Mb (Chr8: 6,938,347–9,639,798) and 0.57Mb (Chr8:10,358,659–16,101,517) on the short arm of chromosome eight were identified responsible for the resistance to gummy stem blight using the Δ(SNP-index) method. The result of QTL linkage analysis with KASP SNP markers further mapped the GSB locus between the SNP marker A009383 and SNP marker A009168 at a genetic distance of 0.4 cM and 0.9 cM, respectively. According to the watermelon gene annotation database (http://cucurbitgenomics.org/organism/1), the region contains about 19 annotated genes and out of the 19 genes, two genes showed disease resistance gene analogs, Cla001017 (Cc-nbs-lrr resistance protein) and Cla001019 (pathogenesis-related). This result will facilitate fine mapping and cloning the gsb-8.1 locus. The tightly linked markers for the gsb-8.1 locus will further provide a useful tool for marker-assisted selection of this QTL in watermelon breeding programs.

**Specified Source(s) of Funding:** National Natural Science Foundation of China

**Ornamentals/Landscape and Turf 2 (Poster)**

**Combating Rose Rosette Disease: Exploring Development of Accurate, Rapid, Efficient, Easy-to-use and Affordable Virus Diagnostic Tools (Poster Board #120)**

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Over the past several decades Rose Rosette Disease has become very serious and threatens to decimate the U.S. rose industry. The causal agent, Rose rosette virus (RRV, Emaravirus), is transmitted by wind-blown eriophyid mites (*Phyllocopites fructiphilus*) and can kill a rose within 2–3 years of infection. A recently-funded USDA, NIFA, Specialty Crops Research Initiative grant involves 17 scientists in six states working on a range of approaches to study this disease and determine how best to manage it. The only strategy currently available for disease management is early identification and eradication of the infected plants, thereby limiting its potential spread. Key to this effort is the development of efficient and affordable diagnostic tools to enable accurate detection of the virus. Molecular- and serological-based assays with potential for technology transfer and/or on-site implementation should be easy to use, offering visual detection, reliability and sensitivity to the end user. RRV-specific primers and probes (for nucleic acid-based tests) and monoclonal and polyclonal antibodies (for serology-based tests) have been developed. The rabbit polyclonal and five mouse monoclonal RRV-specific antibodies can detect viral nucleoprotein (NP) in various ELISA and western-blot formats. Several unique NP-specific epitopes have been identified. Validation of virus detection from field-collected samples is in progress. An additional goal is to produce a serological lateral flow device for in-field diagnosis. Loop-mediated isothermal amplification (LAMP) and thermophilic helicase dependent amplification (tHDA) assays have been developed and are isothermal DNA amplifications which combine several desirable criteria and do not require a thermocycler. A rapid 15 minute probe-based isothermal Reverse Transcription-recombinase polymerase amplification (RT-exoRPA) assay was also developed. Broad detection of Emaravirus and species discrimination was targeted with Reverse Transcription polymerase chain reaction (RT-PCR) coupled to High Resolution Melting (HRM) analysis. A single primer-set suitable for use with three different chemistries [Endpoint RT-PCR, TaqMan-quantitative RT-PCR (RT-qPCR) and SYBR Green RT-qPCR with High Resolution Melting] was also developed. An immune-capture RT-PCR based protocol is also under evaluation. The most consistent assay(s) will be tested and validated by several diagnostic labs and then moved via outreach to other plant diagnostic labs. The contribution of these methods within a holistic perspective of RRV diagnostics will be presented. 

**Specified Source(s) of Funding:** NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

**An Automated Unmanned Aerial System Equipped with a Multispectral Sensor Reveals Abiotic and Biotic Interactions in Commercial Roses (Poster Board #122)**

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With rapid advances in unmanned aerial systems (UAS) and automated multispectral sensing, agriculture professionals are adopting these technologies to manage their operations. Multispectral imaging data in the wavelengths of 550 nm, 650 nm, 709 nm and 820 nm were collected from three commercial fields of roses in California. The automated UAS classified the images based on normalized vegetation difference indices (NDVIs) and identified regions of the fields that appeared stressed. Field verification of these areas indicated that there were interactions between abiotic and biotic stress types. The three main areas identified using multispectral imagery and field verification included: 1) a rapidly drained area with coarse textured soils and rose plants affected with rose rosette virus (RRV), or powdery mildew (Sphaerotheca pannosa var. rosea); 2) an area with excess moisture and drainage issues with a heavy cultivar specific rust infection and two other varieties affected with rose mosaic disease; and 3) a cultivar of Rosa rugosa affected with grey mold (Botrytis cinerea) and minor infections of Cercospora leaf spot (Cercospora rosicola). Here, we show that an automated UAS can identify regions of a field where a combination of poor site factors and disease exist. Future work will involve evaluating multispectral imagery in differentiating between individual biotic stress types and monitoring rose plant health and cultivar-specific flower production.

*Specified Source(s) of Funding: NIFA, SCRI grant “Combating Rose Rosette Disease: Short and Long Term Approaches” 2014-51181-22644/SCRI

Suitability of Recycled Municipal Wastewater for Landscape Perennials Growing in Arid Environments (Poster Board #123)

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Recycled wastewater is a popular alternative water resource. Recycled water typically has a higher salinity than potable water and therefore may not be an appropriate water source for landscapes planted with salt-intolerant plant species. Our previous research demonstrated that recycled wastewater could be detrimental to the growth of long-lived conifer species. We hypothesized that recycled wastewater might also be detrimental to the growth of perennial landscape species. To test our hypothesis, we established a research trial in which we grew varieties of popular landscape perennials (Calibrachoa, Calamagrostis, Deschampsia, Fuchsia, Guara, Hemerocallis, Heuchera, Lavandula, Rosa, Salvia) in pots in a greenhouse with irrigation sourced from recycled municipal wastewater or potable water. In a parallel experiment, we tested the growth responses of six of these varieties (Calibrachoa, Fuchsia, Guara, Lan-tana, Lavandula, Salvia) to elevated levels of irrigation salinity (EC 0.5, 2.5, 6.0). The final component of our study was to determine if the differences in growth between recycled water and potable water were discernable by the public, which could reduce the saleability of these plants. To learn public opinion, we masked the treatment irrigation (recycled or potable water) and surveyed the desirability of the different plants based on a variety of aesthetic qualities. Our results showed that there were no significant growth differences between the plants grown with recycled wastewater and plants grown with potable water (P > 0.05). Accordingly, the public perception was not affected by the irrigation treatment. There is little public research available reporting how people chose plants for their yards. Our plant preference survey can inform researchers and industry members about the acceptability of new species or cultivars that may have certain functional qualities, like drought tolerance, yet may not lack other aesthetic qualities, like lack of flowers. Our results strongly suggest that recycled wastewater is a suitable source for cultivating perennial landscape species. However, the results of our increased salinity trial revealed significant (P < 0.05) negative effects on plant growth at 2.5 and 6.0 EC levels compared with 0.5 EC. These findings suggest that in landscapes where salts will accumulate, such as locations with insufficient leaching that salinized recycled water may present a threat to long-lived herbaceous perennial species.

*Specified Source(s) of Funding: CDFA Specialty Crops Block Grant Program

Florida’s Green Industries Best Management Practices Training Promotes Sustainable Urban Landscapes (Poster Board #124)

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Florida enjoys an abundance of lakes, rivers and coastal waters, many with densely populated urbanized watersheds. Urban landscaping practices, including water, fertilizer and pesticide use, contribute to nonpoint source pollutant loading to surface and ground waters. Landscaping and lawn care is a major busi-
ness in Florida, employing tens of thousands of green industry professionals. To help minimize the potential nonpoint source loading from inappropriate landscaping practices, the UF/IFAS Extension Florida-Friendly Landscaping™ Program, in partnership with the Florida Department of Environmental Protection (FDEP), trains thousands of landscaping professionals statewide through the Green Industries Best Management Practices (GI-BMP) Training Program. State of Florida statutes require this training for all landscaping professionals who apply fertilizers. The training program has four main program goals: reducing off-site transport of sediment, nutrients, and pesticides to surface water or groundwater; promoting appropriate site design and plant selection; using appropriate rates and methods for irrigation and fertilizer application; and promoting integrated pest management (IPM) practices. The GI-BMP training includes six learning modules covering efficient use of water and fertilizer, integrated pest management, fertilizer application, and pollution-minimizing lawn and landscape cultural practices. Course delivery is available through several formats, including in-person classes, or self-paced instruction available online or through a DVD. Courses are available in English and Spanish, with Haitian Creole available through in-person classes. Those persons successfully completing the training and a written exam receive formal GI-BMP certification. Since the program’s start in 2006, over 54,000 persons received training, with 46,067 of these trainees receiving their GI-BMP certification. Surveys conducted 6 months after each training class assess the extent to which trainees have changed their landscaping behaviors and practices to conserve water and reduce pollutants. For 2017, these surveys found that, post-training, 92 to 98% of the attendees used the GI-BMPs on a regular basis, with substantial improvements shown in those who always use the following practices: apply no more than 0.5–0.75 inches (1.27–1.91 cm) water per irrigation event (for water savings of 25 to 50%); reset irrigation controls/timers seasonally; reduce fertilizer application; and use integrated pest management. Further, the post-training surveys documented adoption of new technologies, specifically 72% using soil tests to determine fertilizer needs and 85% using soil moisture or other sensing devices to ensure effective water use.

**Non-destructive Measurement of Bermudagrass Salinity Tolerance** *(Poster Board #125)*

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Turfgrass managers are using reclaimed water as an irrigation resource because of the decreasing availability and increasing cost of fresh, potable water. Therefore, it is important to develop, select, and utilize salinity tolerant turfgrass cultivars. Bermudagrass is a warm-season turfgrass that has relatively high salinity tolerance, but information is needed on the relative performance of both common bermudagrass and interspecific hybrid bermudagrass cultivars and experimental selections. The objective of this study was to evaluate 10 common bermudagrass seeded cultivars and experimental selections and 7 clonal-type bermudagrasses for salinity tolerance using several objective, non-destructive measurement tools. Experiments were performed under a controlled environment with six replications for each treatment. Bermudagrasses were exposed to four salinity levels (1.5, 15, 30, and 45 dS·m⁻¹) consecutively using a sub-irrigation system. Measurements included the subjective human measurements of turf quality and leaf firing, as well as the objective, non-destructive measurements of normalized difference vegetation index (NDVI), digital image analysis (DIA), visual rating with a smartphone app (VR), and dark green color index (DGCI). Correlation analysis showed that the parameters LF, TQ, NDVI, DGCI, and DIA were all highly correlated with one another, indicating that they can be useful as for measurement of relative salinity tolerance among bermudagrass cultivars.

**Response of Five St. Augustinegrass Cultivars to Drought and Recovery** *(Poster Board #126)*

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Water resources are becoming increasingly restricted for use in amenity landscapes, and the inability of water users to characterize drought stress related to plant health can result in inappropriate use of water during drought conditions. St. Augustinegrass *(Sesbania sumatranum) is a widely used warm-season turfgrass found throughout the southern United States and near the Gulf Coast. Data comparing SA cultivar’s performance during extended drought stress conditions and recovery is limited, and existing results are from late summer and fall conditions. Cultivars Delmar, Floratam, Palmetto, Raleigh, and Tamstar were evaluated in a consecutive 60-day drought in spring 2018. Following drought, turf will be evaluated during a 60-day recovery period. Using a rating system, drought response and recovery will be quantified as number of days to increase or decrease to 50% green ground cover. Results may have significant impact on both landscape irrigation behaviors and turfgrass cultivar recommendations.

**Specified Source(s) of Funding:** Sam Houston State University

**Transition Aid Timing Effects on Photosynthetic Rate of Overseeded Bermudagrass** *(Poster Board #127)*

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During winter, bermudagrass *(Cynodon spp.) enters a dormant period resulting in a brown, unattractive appearance and inability to recover from traffic. In some cases, turf managers overseed bermudagrass with perennial ryegrass *(Lolium perenne L.) in order to maintain an actively growing surface during winter and early spring months. An acceptable spring transition back to a bermudagrass surface can be difficult as perennial ryegrass can effectively compete for light and nutrients during this period. Transition aid herbicides have become a commonly-used tool for turfgrass managers seeking to expedite the spring transition.

An asterisk (*) following a name indicates the presenting author.
The objective of this study was to quantify the effect of transition aid herbicide timing on photosynthetic rate and botanical composition of an overseeded bermudagrass turf in Oklahoma. To achieve this objective, a field study was conducted on an overseeded hybrid bermudagrass (C. dactylon × C. transvaalensis ‘Patriot’) field during the winter of 2016–17 at the Oklahoma Agriculture Experiment Station Turfgrass Research Center in Stillwater, OK. The field was mowed three times per week at 25 mm. The experiment was arranged as a randomized complete block with three replications, two products, and eight application dates (between 27 Mar. and 5 June) plus a non-treated control. The products evaluated were foramsulfuron (Revolver) at a rate of 0.13 mL·m⁻² or ammonium sulfate at a rate of 24 kg·ha⁻¹ N. Visual ratings of percent ryegrass, percent bermudagrass, and percent brown straw were recorded throughout the spring transition period. Gross photosynthesis was measured on three dates using a LI-COR 6400XT and a custom chamber. Fertilizer treatments did not show consistent effects (positive or negative) in terms of gross photosynthesis, perennial ryegrass decline, or bermudagrass recovery. Reductions in gross photosynthesis were greater but more delayed after early season applications of foramsulfuron. Perennial ryegrass decline was similarly delayed following early season applications as compared to late season applications. Results suggest applications of transition aid herbicides when soil temperatures (5 cm depth) are above 16 °C result in a markedly faster response than when applied earlier in the season.

**Not Only Green but Sustainable Living Roofs for Guam** *(Poster Board #128)*

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Concrete houses vastly dominate the architecture on the tropical island of Guam. Although they are exceptionally strong in withstanding typhoon winds, they absorb massive amounts of heat that build up during daylight hours and remain in the building material until the next morning. To escape the heat, air conditioning is frequently used and in many houses the air conditioning units run year round, day and night. Concrete roofs are also sturdy enough to carry a load of growing media (soil) and vegetation. This layer of soil covered by plants may effectively shield the roof from the hot sun. Constructing an extensive (minimal maintenance) type of green roof in the tropics can be relatively easy. The growing medium (soil mixed with gravel and lava) needs to be only 10 cm thick and must be placed on some type of drainage layer. On the university campus, a green roof was established on top of a typical one story residential house. Locally plentiful coconut husks (halved and chopped) were placed on the concrete roof and covered by 10 cm of soil. Commercially recommended synthetic drainage material was also used to compare its efficiency with much lower-cost coconut husks. Research conducted examined irrigation needs, the ability of coconuts to absorb and hold water, time needed to deplete water from organic versus synthetic amended plots, as well as daily fluctuations in concrete roof temperature. It was found that shredded husks were the most effective in storing water and ultimately delaying drought stress during dry periods. There were up to a 15 °C difference in exposed concrete when compared to the concrete covered by soil and vegetation. The type of drainage layer had only a minimal influence on roof temperature. Complete data will be presented and discussed.

**Sedum Evaluation for Green Roofs in Oklahoma** *(Poster Board #129)*

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Because of their wide range of environmental and economic benefits, green roofs have become important elements of both small and large scale sustainable landscapes. Plant recommendations vary based on the type of system (extensive or intensive), substrate, as well as the geographical location. Sedums generally do well in both types of systems; however, information on which species and cultivars should be recommended in Oklahoma does not exist. The objective of this study was to evaluate nine different Sedum cultivars planted in an extensive system using a 70:30 ratio mix of calcined clay and compost at a depth of 15 cm. Rooted cuttings were planted late March in 2016 in Stillwater, OK, in a randomized design with eight plants per cultivar. Plants were watered as needed during the summer and no supplemental irrigation was applied in the winter. Of the eight species and 72 total plants, only 25% of plants survived. Recommended species include *S. album* ‘Coral Carpet’, and *S. reflexum* ‘Sandy Silver Crest’, as both had 63% survival. ‘Coral Carpet’ had the greatest growth. *Sedum* ‘Dr. John Creech’ had 37% survival followed by *S. reflexum* ‘Angelina’ and *S. spurium* ‘Fuldaglut’ with both having 25% survival. *Sedum dasyformes, S. japonicum* ‘Tokyo Sun’, *S. confusum*, and *S. spurium* ‘Tricolor’ did not survive past the first year.

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**Plant Biotechnology 2 (Poster)**

**Transgene-mediated Flowerless Plants without Using a Toxin Gene** *(Poster Board #300)*

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The AGAMOUS (AG) gene is required for development of some reproductive organs. Here we report that expression of an rPTAGI::GUS fusion gene is sufficient to produce a flowerless phenotype in tobacco, a model plant. The rPTAGI sequence is an intron sequence cloned from the AGAMOUS gene of poplar. The flowerless phenotype has been observed in both greenhouse and field conditions. We have observed that shoots of the rPTAGI::GUS flowerless plants are flowerless if they are grafted onto wild-type plant rootstocks. On the other hand, wild-type plant shoots flower normally if they are grafted onto rootstocks derived from the rPTAG2::GUS flowerless plants. We have investigated the molecular basis of the flowerless phenotype observed in the rPTAGI::GUS plants via analyses of transcriptomes of shoot tip tissues of both wild type and transgenic plants. We have observed that expression of a number of flowering genes is altered in the rPTAGI::GUS plants when compared to the wild type plants. We believe that the rPTAG2::GUS gene may provide a better tool to reduce pollen- and seed-mediated gene spread problems of transgenic woody plants.

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**The Cold-regulated Genes of Blueberry and Their Response to Overexpression of VcDDF1 in Several Tissues** (Poster Board #301)

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Expression of blueberry cold-regulated genes (VcCORs) could play a role in the variable cold hardness of blueberry tissues. In this study, transcriptome comparisons were conducted to reveal expression of VcCORs in non-acclimated leaves, flower buds, and flowers of both non-transgenic and transgenic blueberries containing an overexpressed blueberry DWARF AND DELAYED FLOWERING gene (VcDDF1), as well as in fully chilled flower buds of non-transgenic blueberry. In non-transgenic blueberries, 57.5% of VcCOR genes showed differential expression in at least one of the three pairwise comparisons between non-acclimated leaves, flower buds, and flowers; and six out of nine dehydration-responsive element-binding factors showed differential expression. In addition, expression of VcDDF1 was not cold-inducible in non-transgenic blueberries and had higher expression in flowers than in leaves or non-acclimated flower buds. In transgenic blueberries, overexpression of VcDDF1 resulted in a higher VcDDF1 expression in leaves than in flower buds and flowers. VcDDF1 overexpression enhanced expression of blueberry CBF1 and CBF3 in leaves and repressed expression of CBF3 in both flower buds and flowers. Overall, the results revealed tissue-specific patterns of VcCORs’ expressions. The response of VcCORs to overexpression of VcDDF1 suggest that it is possible to increase plant cold hardness through overexpression of a non-cold-inducible gene.

**Developing Genetic and Molecular Resources to Improve Spinach Production and Management** (Poster Board #303)

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Spinach (*Spinacia oleracea* L., 2n = 2x = 12) is an economically important vegetable crop worldwide. The objectives of this spinach project are: 1) genetic mapping and SNP marker identification for downy mildew and white rust resistance; 2) QTL and association mapping and SNP marker identification for Fusarium wilt resistance; 3) introgression of downy mildew and white rust resistance into spinach lines with diverse leaf quality characteristics to satisfy market demand; and 4) construction of high density SNP consensus genetic maps of the six chromosomes in spinach using whole genome resequencing. The project is a collaborative effort with the University of Arkansas, USDA-ARS at Salinas, Texas A&M AgriLife, and Washington State University. A total of 480 spinach genotypes are being evaluated for downy mildew, white rust, and Fusarium wilt disease resistance. Downy mildew resistance is being evaluated under...
both field and greenhouse/growth chamber conditions; white rust resistance is being evaluated at the Del Monte White Rust Nursery in Crystal City, TX, and at the White Rust Nursery in Weslaco, TX; and Fusarium wilt resistance is being evaluated in the greenhouse at the Washington State University Mount Vernon NWREC in Mount Vernon, WA, and at the University of Arkansas, Fayetteville, AR. Genotyping is being conducted at BGI and Novogene using genotyping by sequencing (GBS) and whole genome resequencing (WGR). Approximately 500,000 SNPs have been identified in spinach genotypes thus far. Both QTL and association mappings are being used to identify QTLs and SNP markers for disease resistance to the three diseases. The WinQTLCart, Q-gene, and QTLNetwork are being used for QTL mapping, and the general linear model (GLM) and mixed linear model (MLM) from TASSEL, GAlPIT, and FarmCPU will be used for genome wide association studies (GWAS). So far, numerous SNP markers linked to downy mildew resistance locus *Rpf1* have been identified, and SNP markers strongly associated with white rust resistance have been identified. The QTLs and SNP markers will provide breeders with robust tools to improve resistance selection for resistance to these economically important diseases through marker-assisted selection (MAS) and genomic selection (GS).

**A SNP Set for Spinach Cultivar Determination**  
*Poster Board #304*

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Spinach (*Spinacia oleracea* L., 2n = 2x = 12) is an economically important vegetable crop worldwide and one of the healthiest vegetables due to its high concentrations of nutrients and health-promoting compounds. Currently, there are about 400 spinach (*S. oleracea*) accessions in USDA-GRIN. Because spinach is a dioecious species, it is hard to keep each accession as an inbred line and also hard to determine its purity and uniqueness. We develop a 24-SNP set used to spinach germplasm determination to detect and distinguish each spinach accession from USDA germplasm accessions. Based on our genetic diversity analysis among the 400 accessions using SNPs postulated from whole genome resequencing (WGR) and genotyping by sequencing (GBS) data, we select 6 SNPs distributed evenly on each of the six chromosomes in the spinach genome to form a total of 24 SNP set. Using this SNP set, we can detect and determine each accession among the 400 accessions and also this SNP set can be used to determine commercial spinach hybrids, open-pollinated cultivars, and Arkansas spinach lines.

**Genetic Architecture of Abiotic Stress Tolerance in Cowpea through Multiple Genomic Selection Models**  
*Poster Board #305*

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Predictive breeding has become more and more popular in efforts to unravelling the genetic control of complex traits in plants. Cowpea [*Vigna unguiculata* (L.) Walp] is one the most important legumes grown worldwide but significantly affected by various types of abiotic stress. To the best of our knowledge, little has been done with respect to studies pertaining to genomic selection to assist cowpea breeders with efficiently gaining genetic gain. In this study, the focus will be on stresses such as drought, salt, low phosphorus conditions, and iron chlorosis deficiency, which have been proven to substantially limiting cowpea production. Therefore, the objective of this study will be to estimate the accuracy of genomic estimated breeding values (GEBV) for these aforementioned abiotic stresses. Phenotyping on drought, salt, low phosphorus conditions, and iron chlorosis deficiency was conducted on a total of 200, 155, 357, and 353 cowpea accessions, respectively. Genomic estimated breeding values will be computed for at least 1000 SNPs postulated from genotyping-by-sequencing. Training set will consist of subsets randomly chosen from the association panel. Set sampling will be conducted using R through 10-fold cross validation at each sampling process. Genomic selection will be performed in R using rrBLUP, Bayes A, Bayes B, and LASSO. We expect that: 1) genomic selection accuracy will vary from low to moderate depending upon the type of abiotic stress, 2) At least 10 SNPs will have large effects for each trait, 3) Bayes B will provide the highest genomic selection accuracy, and 4) there will be positive correlation between training/testing set size and genomic selection accuracy. The results from this investigation can be used in breeding cowpea cultivars for more tolerance to drought, salt, low phosphorus conditions, and iron chlorosis deficiency.
Genomic Selection-based Approach for Resistance to Aphids and Cowpea Mosaic Virus in Cowpea (Poster Board #306)
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Cowpea [Vigna unguiculata (L.) Walp] is a legume which is widely cultivated in tropical and semi-arid areas. It provides affordable nutritious food for human and is used to feed livestock. Previous investigations reported that cowpea aphid (Aphis craccivora) and cowpea mosaic virus (CPMV) unfavorably affect cowpea production. Phenotyping for resistance to aphids and cowpea mosaic virus could be challenging, time-consuming, and labor intensive, which could slow down the breeding process. Fortunately, this can be addressed by using a genomic selection approach which aims at predicting phenotypes using the information from the genotypes. Therefore, the objective of this study will be to conduct a genomic selection study and to determine the accuracy of genomic estimated breeding values for resistance to aphids and cowpea mosaic virus resistance in cowpea. A total of 333 and 338 cowpea accessions were phenotyped for resistance cowpea aphids and cowpea mosaic virus, respectively. Each association panel will be divided into subsets of training and testing populations using R. Genomic selection will be also conducted in R using rrBLUP, Bayes A, Bayes B, and LASSO. Genomic selection will be performed using a 10-cross fold validation approach. Effects of a total of at least 1000 SNPs will be computed. We expect that: 1) genomic selection accuracy will range from low to moderate, 2) higher accuracy will be obtained using Bayes B, 3) a larger training set will provide higher accuracy for genomic selection, and 4) SNPs from previously reported GWAS will have the largest effects. The results from this study could be used to advance predictive breeding for resistance to aphids and cowpea mosaic virus in cowpea.

Evaluation and Association Analysis of Seed Protein Content in USDA Cowpea Germplasm (Poster Board #307)
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Cowpea [Vigna unguiculata (L.) Walp] is a legume crop grown worldwide to provide protein for human consumption and animal feed. The objective of this research is to estimate the cowpea seed protein content and at the same time conduct association mapping and SNP marker identification for seed protein content in USDA cowpea germplasm. A total of 173 USDA cowpea germplasm accessions were evaluated for their seed protein contents, including 18 accessions with black seed coat color, 26 blackeye, 29 browneye, 12 cream, 8 pinkeye, 15 red, 19 red holstein, 26 tan, and 20 varied color. The field experiment was conducted in two locations within Arkansas State (Fayetteville and Alma) in 2016. A randomized complete-block design (RCBD) with three blocks was used for the experiment in each location. In each plot, cowpea accessions were planted in four rows 10 feet long, with three feet between rows. The seed protein content averaged 25.6%, with a range from 19.6% to 31.0%, and had a standard deviation (Std) of 1.82% with 0.06% Std Error, indicating the seed protein content had large variation in the 173 cowpea accessions. The seed protein content showed difference among the seed coat color: cream and pinkeye seed types had the highest seed protein content with 27.2% and 26.7% respectively; black, blackeye, and browneye second highest with 25.9%, 26.0%, and 26.0% respectively; then, red and tan with 25.3% and 25.3%, respectively; and finally the red Holstein with 23.7%. Association analysis was conducted with the single marker regression (SMR) without structure and without kinship, the regression linear model (GLM), and the mixed linear model (MLM) methods as described in TASSEL 5. Eight SNP markers, C35058883_723, C35069896_1985, C35074656_2002, C35084640_31, C35084640_5600, Scaffold72747_120, Scaffold75749_1913, and Scaffold94454_419 were founded to be associated with seed protein content in the panel of 173 cowpea accessions. This study will provide a tool for breeders how to use USDA cowpea resource and to select high seed protein contents in cowpea breeding program through marker-assisted selection.
Screening of Rose Rosette Primers to Identify the Most Sensitive Primer (Poster Board #308)

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Rose rosette virus (RRV) is a negative sense, single stranded RNA virus. The host for RRV is roses of all classes, as no resistant variety has been identified. Rose rosette disease (RRD) has been a problem in the United States for about 20 years; however the virus was only identified as the causal agent in 2011. Because RRD is a viral disease, there are no known treatments for infected plants. Thus, management requires that infected plants are removed from the landscape slow the spread of the disease. Currently the most accurate way to diagnose a rose with RRV is through Takara Reverse Transcription qualitative PCR (qPCR). However, as this is a costly system, the most common molecular diagnostic for the virus is with Reverse Transcription PCR tests. Unfortunately, there have been many issues with false negative results. This study compared the eight primers developed for four of the seven segments of the Rose rosette virus genome to determine which of the primers is the most effective for the two common diagnostic methods. Samples used in comparison were collected from various parts of Texas along with numerous out of state samples. When comparing the five available qPCR primers for RRV, it was found that primers developed for the third viral segment were the most sensitive for RRV detection. RRV2, which is a primer developed in Oklahoma, was found to be the most sensitive for qPCR detection. When comparing the three available primers for RT-PCR, it was found that the RRV3 primer, from Minnesota, developed for the third viral segment was the most sensitive. The two primers are in different locations on the third segment, but there is little difference in their detection capabilities. The eight primers tested come from four different states and while there were some false negatives, many primers worked for all samples, suggesting that there is little difference in the viral genome across the United States.

Rose Rosette Virus: Effective and Low-cost Extraction Method (Poster Board #309)

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When performing diagnostics on plant samples, it is desirable to use methods that have low inputs of time and money, while still being effective. This is especially true with RNA virus extractions, like ones done for the diagnosis of Rose rosette virus. The kits that are used in RNA extraction are typically costly and time consuming, with some kits taking as much as two hours per sample. From a diagnostic stand point, this is high time input, especially when other diagnostic procedures can be completed quickly. Whenever the need arose to extract 100+ samples at a time, the kit extraction methods were not feasible for use because of the costs and the time required. Recently a direct antigen extraction method was developed for the Rose rosette virus. However, this method is still time and resource consuming and not for practical use in a diagnostic lab. This cost effective direct antigen extraction method was modified to allow for rapid extraction (15 min. per sample) and the use of common resources in diagnostic clinics such as mesh bags and phosphate-buffered saline/tween (PBST). Extracts using the modified direct antigen method and the Qiagen RNeasy Plant Mini Kit are similar in sensitivity. The extracts are stable for repeated use, however Ct values on Takara Reverse Transcription quantitative PCR (qPCR) tend to increase by 1–2 cycles after repeated freeze-thaw cycles on the extract. However, most diagnostic labs do not retain extracts for research, so this may not be a problem. This extraction method is also effective at extracting stable RNA with other rose RNA viruses that can be used for detection.

Postharvest 2: Fruit (Poster)
Changes and Quantifications of Eight Major Plant Growth Regulators during Non-climacteric Ripening in Strawberry Fruit (Poster Board #251)
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Strawberry fruit (Fragaria × ananassa) has been considered as non-climacteric fruit. However, the roles of other major plant hormones and ripening mechanism of strawberry fruit have not been well studied clearly. To understand hormonal regulation mechanism of strawberry fruit ripening, we analyzed eight major hormones of abscisic acid (ABA), indole-3-acetic acid (IAA), gibberellin 4 (GA₄), jasmonic acid (JA), methyl-jasmonate (MJ), jasmonoyl isoleucine (JA-Ile), salicylic acid (SA) and ethylene (ET) according to strawberry fruit development stages. The quantification of hormones was conducted at six developmental stages: S1, small green; S2, green; S3, breaker; S4, pink; S5 red and S6, fully red coloration. IAA and GA₄ levels showed the highest levels at S1 stage and gradually declined during the fruit development. The level of ABA was low at from S1 to S3 stages and then rapidly increased at S6 which showed the maximum value. In contrast, the level of MJ did not significantly change during the fruit development stage. SA increased gradually during strawberry fruit ripening. JA and JA-Ile were detected but not enough to quantify as a trace amount. ET was not detected in all fruit development stages. Additionally, the ABA biosynthesis genes of FaNCED1 and FaABA2 had positive correlations with fruit ripening. The
ABA degradation genes of FaCYP707A1, FaUGT75C1 encoding 8-hydroxy-lase had negative correlations with fruit ripening. The transcription factor expression levels of FaMYB1, FaMYB5, and FaMYB10 increased with the ripening of strawberry fruit. Therefore, the ripening of strawberry fruit would be controlled under the changes of ABA and its transcriptional regulations.

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**Metabolic Responses of Amino Acids and Volatile Organic Compounds to Fruit Ripening Stages and Shelf Life in ‘Seolhyang’ Strawberry Fruit** (Poster Board #252)

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Strawberry fruit develops a complex flavor during ripening. The objective of this study was to evaluate the metabolic responses and relationship between amino acids and volatile organic compounds (VOCs) during ripening and shelf life of ‘Seolhyang’ strawberry fruit. Fruit were harvested at green, pink, and red maturity stages and left at ambient temperature for 7 days for shelf life. Fruit were harvested at green, pink, and red maturity stages and left at ambient temperature for 7 days for shelf life. Fruit fresh weight, diameter, and length decreased during 7 days shelf life, compared with fruit at harvest at all maturities. Soluble solids content (SSC) and titratable acidity (TA) decreased with maturity. SSC remained unchanged with shelf life while TA increased. Levels of aspartic acid, glutamic acid, valine, isoleucine, leucine, tyrosine, phenylalanine, histidine, arginine, and proline declined with shelf life while β-alanine and γ-amino-n-butyric acid (GABA) levels increased. Levels of ethyl acetate, methyl butanoate, ethyl butanoate, methyl hexanoate, butyl butanoate, ethyl hexanoate, and hexyl acetate increased but hexanal, (E)-2-hexenal and 2-heptenal responses decreased with shelf life. Overall, the inverse relationship between amino acids and certain VOCs that occurred with increasing fruit maturity and continued during 7 days shelf life. These results indicate that amino acids may be involved in VOCs production during shelf life.

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**Potential of Programmed Cooling to Expand Handling Options for Fresh-market Strawberry: Semi-commercial Scale Tests** (Poster Board #253)

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Fresh-market strawberries grown on commercial scale are typically picked, field-packed and transported for forced-air (FA) cooling within 1–2 h of harvest. FA cooling typically requires 60 to 180 min. to achieve 7/8 Cooling. Our previous studies with blueberries showed that fruit cooled to 10 °C by FA cooling day of harvest, held overnight, then 7/8 cooled the following day had similar fruit quality during subsequent storage as fruit completely cooled with FA the day of harvest. We also demonstrated that strawberries in clamshells that were partially cooled by immersion hydrocooling (HY) cooled more rapidly and uniformly (8 min.) than those cooled by FA (61 min.). Successful HY requires constant sanitation of the cooling water (100–150 ppm free chlorine; pH 6.8–7.0). The result is strawberries that have been rinsed and sanitized prior to shipping. We term this procedure “programmed cooling”, or the deliberate partial cooling of fruit or vegetables for defined times prior to final cooling, with minimal effect on storage quality. The objective of these tests was to determine the effect of six programmed-cooling scenarios on strawberry quality (‘Sweet Sensation’), considering delay from harvest (immediate cooling versus 1.5 h), holding temperature (ambient or 10 °C) and HY versus FA. Tests were conducted during March and April of 2018 at a commercial farm. Partially cooled treatments were 7/8-cooled with FA, stored at 1°C for 7 days and evaluated quality. There was no statistical difference in strawberry quality due to cooling regime. Firmness ranged from 2.3–3.5 N, fruit brix:acid ratio was 10 and external hue* value of 30–35°. The incidence of bruising was quite high for all treatments, even at the initial evaluation (37% to 65%). This could be a result of unexpected late season cold weather and heavy rain events. Use of programmed cooling shows potential to provide more handling options for strawberry growers.


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Three exciting new peach (‘Evelynn’, ‘Selena’, and ‘Tiana’) and two nectarine cultivars (‘Brigantine’ and ‘Silverglo’) have been released from the Rutgers Stone Fruit Breeding Program. These new varieties were created and selected by Joseph Gofreda at the Rutgers Fruit and Ornamental Research Extension Center in Cream Ridge, New Jersey. To understand how best to select and market these varieties, growers need to better un-
understand the characteristics of their fruit. We performed three years of studies (2015–2017) to estimate fruit qualities, both chemical and physical, that determine much of the value of peaches. For each study fruit were harvested from three to five-year-old trees established in commercial orchards in southern New Jersey. Harvesting at the time of commercial maturity for each cultivar was based on ground color change and size. After picking, fruits were transported to the laboratory at Rutgers Agricultural Research and Extension Center, where all analyses were performed. Fruit were evaluated for firmness, size, total soluble solids (%Brix), total titratable acidity, and pH. ‘Evelynn’ has produced large fruit with very good firmness that are low in acid, giving them a sweet and delicate flavor. ‘Selena’ are late season yellow, firm-fleshed peaches with excellent firmness and can hang well in the tree. ‘Tiana’ has yielded consistently firm, large fruit that are sweet and acidic giving them a tangy flavor. ‘Brigantine’ has produced very attractively finished fruit with good size and firmness that are sweet, acidic and tangy in flavor. ‘Silverglo’ is very firm, and larger and more attractive than other white nectarines during their early harvest window. These five varieties can be recommended for trial planting or replacing poorly performing, concurrently harvested peach or nectarine varieties.

Specified Source(s) of Funding: New Jersey Peach Promotion Council

**Cause of Shrunken Shoulders in ‘Tommy Atkins’ Fruit Grown in Diverse Ambient in Mexico** *(Poster Board #255)*

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In ‘Tommy Atkins’, it is common to find a high percentage of fruit with ‘shrunken shoulders’. The objectives of this work were to study if fruit ripening degree, quarantine hot water treatment (QHWT), hydrocooling, rest after hydrocooling, and nutritional status of the orchard influence this anomaly in ‘Tommy Atkins’ fruit. The study was conducted during the 2017 season with fruit harvested in Jalisco, Nayarit, and Sinaloa. Treatments included: 1) origin; 2) ripening degree (partial ripe and ripe); 3) time of QHWT (75 or 90 min.); 4) hydrocooling (immediate, after 30 min and without); and 5) rest (without or rest for 24 h). Once the treatments were applied, fruit were stored for seven days in refrigeration [53.6 ± 1.5 °F; 95 ± 5% relative humidity (RH)] and then under marketing simulation (71.6 ± 3 °F; 75 ± 10% RH) until consumption stage. Sampling was done at the beginning and end of the refrigerated storage and at consumption stage. Variables measured were percentage of shrunken shoulders, weight loss, firmness, pulp color, and total soluble solids content. A completely randomized design with a factorial arrangement was used. Results showed almost 30% of fruit with shrunken shoulders. Fruit harvested in Jalisco did not show the damage whereas fruit from Nayarit and Sinaloa had 27.1 and 28.3% damage, respectively. The factors that most influenced presence of shrunken shoulders symptoms were ripening degree at harvest and rest. Fruit harvested partially ripe showed a higher percentage of this anomaly in all the samplings. At the beginning, the partially ripe fruit showed 18.1% of fruit with shrunken shoulders, as compared to only 3.9% of the ripened fruit. At the end of refrigeration, partially ripe fruit increased shrunken shoulders symptoms to 25.3%, while ripened fruit showed only 8.9%. At consumption stage, the partially ripe fruit had 25.6% of fruit with symptoms, while ripe fruit only 11.4%. The other factor that significantly influenced the presence of fruit with shrunken shoulders was the rest, mainly in the initial sampling, where the fruit with rest of 24 h showed three times more fruit with symptoms (16.1%) than those without rest (5.8%). In conclusion, to reduce or avoid the incidence of fruit with shrunken shoulders, it is recommended to harvest ripe fruit, as well as to avoid a rest period of 24 or 48 h traditionally carried out by the packers.

Specified Source(s) of Funding: National Mango Board

**Effects of Site and Cultivar on Consumer Acceptance of Pomegranate** *(Poster Board #256)*

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Pomegranate (*Punica granatum L.*) is an important fruit in many cultures. The fruit and juice have risen in popularity as it was discovered that pomegranate has relatively high antioxidant activity compared to most other fruits. In this study, six cultivars were utilized to determine consumer acceptance compared to the industry standard, ‘Wonderful’, which comprises 90 to 95% of commercial production in the United States. Fruit were sourced from two cultivar field trials, one in inland Riverside, CA, and one in coastal Ventura County, CA. Cultivars selected for the study included Eversweet, Green Globe, Haku Botan, Loffani, Phoenicia, Wonderful, and cv. 857, an heirloom cultivar from Ventura County, CA. Pomegranate arils were subject to sensory evaluation by 87 untrained consumer panelists in late 2016. Panelists were given pomegranate arils and asked to score the samples using a 9-point Hedonic scale for the following fruit quality traits: aril color, sweetness, tartness, seed hardness, bitterness, and overall desirability. There were significant differences...
Impact of Preharvest Weather Conditions on the Incidence of Apple Fruit Storage Disorders

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Inter-annual variability in apple fruit storage disorders is associated with weather conditions during fruit development prior to harvest. Bioclimatic models for apple phenology, pests (insects and diseases), and storage disorders to assess risks associated with this weather variability were implemented in CIPRA, a computer system that uses real time weather data to assist crop producers in their daily decision-making process. The objective of this study was to update existing apple storage disorder models and develop new models based on fruit quality data collected over many years and sites in Eastern Canada. ‘Honeycrisp’ apples are quite susceptible to a number of storage disorders such as soft scald, soggy breakdown and bitter pit. ‘McIntosh’ and ‘Empire’ apple fruits show susceptibility to low temperature disorders such as vascular browning and core browning, respectively. Apple phenological data, weather data during fruit development and storage disorder incidences were collected over many years with the objective of identifying which weather parameters influence storage disorder incidences. Data from apple orchards were obtained on ‘Honeycrisp’ and ‘McIntosh’ in Ontario (2002–06), and on ‘Honeycrisp’, ‘McIntosh’ and ‘Empire’ in Ontario and Quebec (2009–17). The following weather data and parameters were measured or estimated:
- daily precipitations, maximum and minimum air temperatures, solar radiation, potential evapotranspiration and water balance, during six sub-periods of fruit development, expressed in days after flowering (DAF): 0–14, 15–29, 30–44, 45–59, 60–89, and 90–harvest.
- Every year in each commercial orchard, apples were harvested at optimum maturity for storage and were evaluated immediately for fruit quality, including firmness, soluble solids content and starch index. They were then placed into air or controlled atmosphere storage for up to 10 months. The incidence of all storage disorders was assessed at the time of storage removals and seven days later. All data for each storage disorder were analyzed using principal component analyses and stepwise linear regressions to establish the effect of weather after each sub-period of fruit development. For the years and sites of this study, results from these bioclimatic modelling activities show that weather during apple fruit development, as soon as 45 DAF, explains an important part of the observed variability of all storage disorder incidences in Eastern Canada. Such bioclimatic models will be very useful tools for apple producers in their marketing and storage strategies in order to provide high quality apples to their consumers.

Cooperative Effects of Preharvest Calcium and Gibberellic Acid on Tissue Calcium Content and Quality Attributes of Sweet Cherry

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In the U.S. Northwest, sweet cherries that are shipped to distant markets are subject to various arrival issues including fruit softening, flavor loss, skin darkening, pitting, splitting, pedicel browning, and decay. The objectives of this study were to develop preharvest calcium (Ca) and gibberellic acid (GA$_3$), separate or in combination, spray protocols to improve cherry harvest/shipping quality. Six weekly applications of 0.15% Ca were required between pit-hardening and one week before harvest (WBH) to increase fruit tissue Ca concentration of ‘Lapins’. Two applications of Ca applied at pit hardening and WBH did not improve tissue Ca concentration compared to the 6-application regime. For 0.15% Ca + 25 ppm GA$_3$, application, GA$_3$ was applied a single time, alone or combined with Ca, at pit-hardening, then afterwards Ca was sprayed five weekly to 1 WBH. Soluble solid (SSC), titratable acidity (TA), and fruit diameter at harvest were not affected by the Ca + GA3 applications, while fruit firmness and tissue calcium content of ‘Skeena’, ‘Lapins’ and ‘Regina’ were significantly increased compared to the alone Ca or GA$_3$ applications. Ca + GA$_3$ treatment improved shipping quality by enhancing tissue Ca content, reducing cracking, surface pitting, decay, pedicel browning, skin darkening, and loss of firmness and TA after 4 weeks of cold storage.


**Measurement and Evaluation the Development of Melting Texture in European Pears Using Hygroscopic Holding Capacity (Poster Board #259)**

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Melting (buttery and juicy) texture is one of the most important traits in European pears (*Pyrus communis* L.) affecting consumer purchasing decisions. Flesh firmness (FF) and extractable juice (EJ) are the currently two indicators for predicting eating potential in European pears. However, many people do not understand why the fruit developed a characteristic of juicy during melting texture development is associated with a loss in EJ. In this study, we developed a simple and rapid method for evaluating the melting texture in pear flesh based on the holding of the water by water-soluble polyuronides (WSP), hygroscopic holding capacity (HHC), after extractable juice was removed from the flesh sample. The HHC data were monitored in three pear cultivars (‘Bartlett’, ‘Golden Bosc’, and ‘d’Anjou’) following regular-air (RA) storage plus a ripening period at 20 °C in two years. There was a high negative correlation between EJ and HHC ($r^2 = 0.996$ in ‘Bartlett’, 0.884 in ‘Golden Bosc’ and 0.928 in ‘d’Anjou’). The development of HHC was negatively correlated with FF and EJ, while positively correlated with WSP and melting texture. The factors of cultivar, harvest maturity, produced elevation, storage duration, storage temperature and controlled atmosphere (CA) affected the development of HHC in pears. HHC may be used as a critical melting index with FF in European pears due to its significant increase during ripening.

**Water Utilization and Management (Poster)**

**Can Reclaimed Wastewater from Local Breweries be Used to Produce High-value Urban Crops? (Poster Board #210)**

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Modern agriculture faces many challenges for increasing production to meet growing global food needs. Agriculture is water intensive, and changing precipitation and temperature patterns threatens water availability in many parts of the world. Hydroponic crop production is water and fertilizer efficient but is dependent on synthetic fertilizers and good water quality. Urban agriculture can play a key role in reusing water and nutrients in urban environments. Irrigation with municipal wastewater from food industries may be an alternative to reclaiming wastewater and capturing excess nutrients. Brewery wastewater has a moderate nutrient load and a reduced presence of pathogens and heavy metals, which makes it ideal for agriculture. Treating this water in a decentralized way prevents it from further contamination. Decentralized treatment paired with urban agriculture could allow for water reuse and reclaim the nutrients for food production. This has the potential to help enhance food security while protecting the environment and creating new economic opportunities. In this project, we have developed a system where wastewater from breweries is treated in situ and the effluent is used to produce leafy greens and herbs in a non-circulating hydroponic system and substrate based production. Wastewater is first treated using an anaerobic reactor that obtains energy as hydrogen and reduces the carbon load of the water. Treated wastewater is adjusted for the optimal pH and electrical conductivity and used for hydroponic production as well as in soilless substrate-based production. Crop yields are compared to plants grown using a commercial hydroponic solution. Preliminary results show significant lower yields in the plants grown using wastewater. Successful development of the model and greater understanding of nutrient mineralization in hydroponics will allow for a decentralized treatment technology and promotion of soilless urban agriculture.

**Nitrate Leaching Index for Lettuce Subjected to Different Irrigation Regimes (Poster Board #211)**

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Nitrate ($NO_3^-$) contamination of groundwater is a significant unresolved environmental issue worldwide. Any nitrogen (N) fertilizers not taken up by shallow rooted vegetable crops with high demand for N, such as lettuce, can leach to the groundwater. Adoption of a preventative strategy to mitigate nitrate contamination of groundwater is critical for controlling the amount of nitrate below the root zone while optimizing crop yield. When combined with the appropriate fertilizers, surface drip irrigation can be a useful tool to help mitigate the nitrate leaching potential of a lettuce crop. The overall goal of our on-
Poster Presentations

Improving Irrigation Scheduling for Fruit Trees in the Southeastern United States
(Poster Board #212)
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Irrigation scheduling in fruit tree orchards requires measurements that are easy to translate into irrigation advice. Many growers in the Southeastern U.S. irrigate their trees only based on rainfall records, visual monitoring of tree and fruit growth, and estimating soil moisture with a hand squeeze test. Measuring soil tension with tensiometers is becoming more common since they are relatively affordable but, depending on the soil type, they may only indirectly reflect the tree water status. Tree-based water status indicators have been proven to be the best indicators for irrigation of tree orchards. However, drastic variation in daily environmental conditions, especially relative humidity and temperature, make difficult their application. The goal of this project is to improve the correlations and adjusted coefficients between soil and tree measurements to improve irrigation scheduling in fruit tree orchards. Tensiometers allowed the comparison of soil tension readings with dendrometers that measured the micro-variations in the tree trunks caused by movement of water. The maximum daily shrinkage (MDS) of the trunk diameter showed remarkably more variability under water deficit than the well-watered peach trees. Nevertheless, the daily fluctuating environmental conditions of South Carolina, especially relative humidity and temperature, seemed to be the main challenge to correlating values between the dendrometers to the tensiometers. Tensiometers deeper than 12” did not correlate to the tree based sensors at all. Humidity levels on days that were reading differently than expected were explored as well as when those humidity levels had a dramatic daily change compared to the MDS in stressed trees versus non-stressed trees.

Specified Source(s) of Funding: CSU- Agricultural Research Initiative (ARI)

Location, Location, Location: The Influence of Topographic Position on Plant Health in Bioswales Along I-95 (Poster Board #213)
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Plants are critical components of the sustainable stormwater management systems, as they provide both ecosystem services and aesthetic value. However, plant health and survival can be compromised by the extreme hydrological conditions that characterize stormwater systems, as well as by the salts and contaminants present in stormwater. We determined how the health of nine plant species varied as a function of exposure to stormwater in large bioswales that capture runoff from a section of Interstate 95 in Philadelphia. We evaluated canopy size, leaf areas, and leaf-level physiology in 72 plants (eight per species) after two years of growth; individuals within each species were selected such that they spanned a wide range of micro-topographic positions. For the majority of species (Asclepias incarnata, Calamagrostis × acutiflora, Hemerocallis, Iris sibirica, and Monarda didyma), canopy volumes became progressively smaller as plants were positioned lower in the basins. Two additional species (Cornus sericea and Viburnum trilobum) had reduced canopy sizes at both low and high topographic positions. However, leaf-level physiological rates exhibited a very different range. Although the growth of most species was strongly reduced when plants grew in wetter soils, our results suggest that

Specified Source(s) of Funding: South Carolina Peach Council

An asterisk (*) following a name indicates the presenting author.
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Nonpoint source pollution is the leading contributor to impairment of water quality in rivers and streams within the United States. Nationally, 12% of storm water nutrient runoff is estimated to originate from urban residential landscapes. Street sweeping is regularly performed within cities and residential communities to reduce leaf litter, soil, and roadway debris that may otherwise compromise functioning of storm water management systems. Removal of plant and soil debris through street sweeping activities may also reduce nonpoint source pollution. To assess the effect of street sweeping on storm water pollutants, 36 storm water collection devices were installed within six residential communities in Central Florida. Areas within communities were randomly assigned to be swept or not swept. Precipitation and storm water retention pond leachate samplers were installed to quantify pollutant sources that may enter and leave selected urban communities. Despite high variability in percentage of impervious surfaces, population density, and volume of road debris among communities, no significant ($P \leq 0.05$) differences were observed for total Kjeldahl nitrogen (TKN), nitrate + nitrite (NOx), and total phosphorus (TP) concentrations in storm water among communities or between swept and unswept areas of communities. Similarly, no significant differences were observed for TKN, NOx, and TP concentrations in precipitation and storm water. Significant differences in orthophosphate (ortho-P), however, were observed between communities and precipitation. Additionally, storm water TP concentrations were greater than discharge estimated to originate from communities within the study area. Although street sweeping may be effective at reducing volume of roadway debris, our data did not find it reduced N or P in storm water discharged from selected urban communities in Central Florida.

Potential Phosphate Removal from Nursery Runoff Water Using an Iron-based Remediation System (Poster Board #216)

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Phosphorous (P) applications in containerized plant nurseries are essential for the growth of healthy plants. However, due to the low nutrient holding capacity of soilless media, some P not utilized by plants may leach into drainage systems and downstream water bodies where it can contribute to eutrophication and reduce water quality. As environmental regulators establish and enforce nutrient criteria, effective methods are needed to reduce amounts of P in runoff and drainage water. This study investigated the use of a small scale flow-through ferrous iron [Fe(II)]-based remediation system to chemically precipitate P. This system was developed as an add-on module

Storm Water Surface Runoff and Road Debris from Urban Communities As Sources of Water Pollution (Poster Board #215)

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Where’s My Water? Spatial Distribution of Water within Containers Revealed by X-Ray Tomography (Poster Board #217)

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growing media consists of mixtures of substrate components such as peat, pine bark, and coir. These components provide structure within the container to support plants and supply the essential water, air, and nutrients to promote plant growth. Factors which may affect air and water status within containers are the substrate components, container height, and irrigation practices. Understanding how these factors influence the retention and distribution of water within a container is essential in promoting water-use efficient practices. However, visualizing and quantifying the spatial distribution of water within a container has been difficult due to the opaque nature of substrate components. Recent advances in X-ray tomography and commercially-available analytical software have allowed researchers in plant and soil science to 3-dimensionally visualize and quantify plant-soil-water relations. Using a high-resolution X-ray microtomography scanner, the spatial distribution of water within various substrate components were volumetrically and spatially quantified after three irrigation practices were applied: overhead, drip, and sub-irrigation. As expected, water content increased from the top of the container to the bottom following irrigation. The layer commonly referred to as the “zone of saturation” in substrates was quantitatively characterized. For example, following an application of overhead irrigation, a pine bark substrate’s zone of saturation extended 2 cm above the base of the container and contained approximately 0.12 cm³ of air filled porosity. These results indicate that X-ray tomography is well equipped to assist researchers in understanding the dynamic interactions between substrates, containers, and irrigation practices.

Sensor-Based Technology to Optimize Irrigation Scheduling in Drip-irrigated Vegetable Systems (Poster Board #218)

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The sustainability of irrigated vegetable cropping systems is highly dependent on the effective management of water resources. This is particularly relevant in arid regions such as California which are highly impacted by climate variability and diminished water supplies. Thus, water conservation has become a top priority in the state and has required vegetable producers to adopt management practices that optimize irrigation and water use efficiency. One approach to improve irrigation efficiency is to implement irrigation scheduling practices to accurately estimate crop water requirements and determine how much and when to irrigate. Such implementation can be accurately and timely conducted with the use of sensor technology. Many sensors and data logging equipment are currently available to trigger irrigation applications based on measurements of crop evapotranspiration (ET) or soil water content. To evaluate these options and assess their effectiveness in optimizing irrigation and water use efficiency, we conducted field studies on various crops (lettuce, tomato, broccoli) which were drip-irrigated following an ET- and a soil sensor-based scheduling approach. The study site, located at California State University, Fresno, was characterized by sandy loam soils. For the ET-based approach, an irrigation scheduling program was developed to 1) poll daily ET data from a local state weather station using the CIMIS web Application Programming Interface (API) over radio and internet links, and 2) calculate daily irrigation applications. For the sensor-based approach, six capacitance-soil moisture devices installed at three locations and two depths (6” and 12”) were used with a datalogger and a 24VAC solenoid valve. Irrigation scheduling was programmed using upper (field capacity) and lower thresholds (30% maximum allowable depletion) of soil available water. Irrigation applications were triggered when the average soil moisture values reached the lower threshold and ended after field capacity was attained. In addition, some fields were irrigated based on visual crop and soil observations and manually operating irrigation valves. Results show that both ET- and soil sensor-based technology can improve water use efficiency and help growers optimize their irrigation scheduling.
Weed Control and Pest Management 2 (Poster)

Macrohormina phaseolina Biomass Accumulation in the Presence of Fungicide Treatments In Vitro (Poster Board #174)

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Interspecific hybrid impatiens have been recently identified as a host for the soil-borne fungal pathogen Macrohormina phaseolina. No control methods for this fungus have been developed in impatiens for growers, landscapers, or homeowners. The goal of this study was to screen the efficacy of three commercially available fungicides (Tanos, Banrot, and T-Bird) on biomass accumulation of M. phaseolina (isolate MP1) in vitro. To accomplish this, M. phaseolina was grown in liquid basal media containing one of the three fungicides at 0.25x, 0.5x, 1.0x, or 2.0x the recommended application rate in a completely randomized design. All samples were grown at 27 °C and shaken continually to keep the fungus suspended and the media oxygenated. Biomass accumulation was quantified using dry weights of the samples taken at three sampling dates. Banrot applied at 2.0x concentration and T-Bird applied at 1.0x concentration were the most effective at reducing dry weights of M. phaseolina by more than 25%. The greatest reduction (31.7%) was achieved by T-Bird at 1.0x concentration. M. phaseolina treated with Tanos 0.25x were 12.5% larger than the controls after 3 weeks; however, it was able to limit growth at the 2.0x concentration. Future work will include field trials to determine the efficacy of Banrot and T-Bird in situ. This will include identifying the optimal rates and application time to control the pathogen.

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Efficacy of Biofungicides to Control Pythium Root Rot and Damping-Off in Lettuce (Lactuca sativa) Seedlings (Poster Board #175)

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Pythium root rot and damping-off is a common disease in greenhouse crops including lettuce grown in hydroponic systems. Synthetic chemical products registered for specific use in hydroponic production systems in greenhouses are limited. The objective of this project was to assess the efficacy of microbial biofungicides for control of root rot caused by Pythium spp. in lettuce (Lactuca sativa cv. Rex and Spretnak) seedlings. Seven day old lettuce seedlings were treated with Companion (Bacillus subtilis GB03), RootShield Plus (Trichoderma harzianum T-22 and Trichoderma virens G-41), Triathlon BA (Bacillus amyloliquefaciens D747), and Cease (Bacillus subtilis QST713) following specimen label instructions. One day after treatment, the plants were inoculated with Pythium spp. at 1 x 10^5 zoospores per mL. After seven days, we measured root necrosis, disease incidence and severity, fresh and dry shoot and root weight. Lettuce plants infected with Pythium spp. had between 73.9% and 86.5% lower shoot and root dry weight than non-inoculated plants, respectively. All plants inoculated with Pythium and treated with microbial biofungicides were bigger than plants inoculated with Pythium and no microbial biofungicides. Root necrosis was observed in all plants treated with Pythium. However, differences in plant wilting and mortality were not observed between treatments. We did not see any damping-off. Results from this experiment suggest that beneficial microbes can reduce the negative effects of Pythium spp. infection at the seedling stage. However, in the absence of disease, biomass was reduced by the microbial biofungicides.

Specified Source(s) of Funding: USDA via the Connecticut Department of Agriculture – Specialty Crop Block Grant # AG151260

Antifungal Activity of Sulfur Compounds Against Sclerotinia minor (Poster Board #176)

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Sulfur has been used to control plant pathogens such as Uncinula necator and Botrytis cinerea. Sulfur compounds such as allyl-isothiocyanate are registered as fumigants, but some sulfur compounds have not been tested against soilborne pests. The objective of this study was to test the antifungal activity of allyl-isothiocyanate (commercial name: Dominus), water and ethanolic extracts of mustard seed meal (MSM), and allicin against mycelial growth and sclerotial germination of Sclerotinia minor which can cause significant economic losses in lettuce fields. MSM was extracted by distilled water (1:5) or 99% ethanol (1:5, 1:2.5, and 1:1.25). The extract of one mL was added to 100 mL potato dextrose agar for the agar dilution test. The concentrations of allicin and allyl-isothiocyanate were 5.4, 10.8, and 14.4 mg·mL^-1 respectively. As the concentration of ethanolic extract of MSM increased, the mycelial growth and sclerotial germination of S. minor decreased significantly. Allyl-isothiocyanate at 500 µL·mL^-1 completely inhibited the mycelial growth and sclerotial germination of S. minor. To verify the effectiveness of short-time exposure of the sulfur compounds, the sclerotia were dipped into aqueous solution of the sulfur compounds for one minute. The sclerotial germination was inhibited by allyl-isothiocyanate, ethanolic extract of MSM, and allicin until...
the fourth day after the dipping. The results indicated that the sulfur compounds, except water extract of MSM, demonstrated antifungal activity against the growth and germination of S. minor, and the compounds may be potential sources of natural fungicides and fumigants. Further investigation is needed to increase the duration of effective control.

Specified Source(s) of Funding: USDA NIFA Methyl Bromide Transition Program

**Powdery Mildew Control and Spray Application Characteristics of a Laser-guided Sprayer (Poster Board #177)**

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A variable rate sprayer was developed that applies pesticides based on real-time scanning laser rangefinder measurements of plant presence, size, and density. The objectives of this experiment were to evaluate 1) control of dogwood powdery mildew and 2) characterize spray applications to Cornus florida in a multi-row block from the newly developed laser-guided “intelligent” sprayer and a conventional air-blast sprayer. Water sensitive cards (WSCs) were placed in ‘Cherokee Princess’ flowering dogwood trees prior to each of four fungicide applications to characterize spray penetration and drift. Cards were analyzed for coverage (%) and droplet density (deposits/cm²) using the DepositScan program. Powdery mildew severity was ranked weekly throughout the season. Whole trees were rated on a 0–4 scale following Hagan et al. 1998 with 0 signifying no disease and 4 signifying 76 to 100% disease. Increase in plant height over the season was 49 and 48 cm for the intelligent and conventionally sprayed trees, respectively. Tree disease ratings were 0 and 0, 0.75 and 0.625, and 0.58 and 0.50 for intelligent and conventionally sprayed trees, respectively. On 26 May, 28 June, and 27 July 2017, the overall tree disease ratings were 0 and 0, 0.75 and 0.625, and 0.58 and 0.50 for intelligent and conventionally sprayed trees, respectively. Intentional spray coverage and droplet density on WSCs were ranked throughout the season. Whole trees were rated on a 0–4 scale following Hagan et al. 1998 with 0 signifying no disease and 4 signifying 76 to 100% disease. Increase in plant height over the season was 49 and 48 cm for the intelligent and conventionally sprayed trees, respectively.

**Exposure and Behavioral Assays of OMRI Approved Insecticides on Green Lacewing, Chrysoperla Rufilabris (Poster Board #178)**

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Tomatoes (Solanum lycopersicum) are susceptible to a wide array of arthropod pests. Varieties on the market do not have pest resistance incorporated to allow for a reduction of pesticides used on the crop. In protected culture, using biological control agents is a critical part of insect pest management (IPM), especially for the control of the two major pests: whiteflies and aphids. Limited research is available on the effect of Organic Materials Review Institute (OMRI) approved insecticides on biological control agents in protected culture. We evaluated the selectivity of five OMRI approved insecticides against 2nd instar larvae of the generalist beneficial control agent, Chrysoperla Rufilabris, in triple exposure and behavioral assays. Triple exposure assays were conducted with thirty 2nd instar larvae per treatment with positive and negative controls and five insecticides applied at the highest rate on the label. Insects were monitored daily for mortality and developmental time points. All insects treated with the positive control, DEET, died within an hour. Two thirds of the Azatin-O® treated larvae pupated and delay of a day and a half was statistically different from the control and four other insecticides, EcoTec®, M-Pede® PyGanic® and SucraShield®. None of the Azatin-O®-treated larvae produced adults compared to over 90% for the other treatments. Behavioral assays were conducted with the same treatments versus a control using thirty 2nd instar larvae per treatment with the ViewPoint™ tracking system, where data was collected on ambulatory time, distance walked, velocity, and proportion of time spent in each half of the arena for 10 minutes. This assay violates ANOVA assumptions of normality and homoscedasticity thus, the Wilcoxon rank sum test was used to test the significance of differences in treatment response. C. Rufilabris larva expressed repellency characteristics upon contact of DEET in the paired behavioral assays based on Wilcoxon Signed-Rank Test for ambulatory time, distance and % time, but not velocity. The acetone control showed no significance for any parameter. Larvae exposed to Azatin-O® had a significant response to the distance traveled. While PyGanic® had a significant effect on the velocity of the larvae, which was no surprise since if they encountered PyGanic.
Introducing a New Codling Moth Biofix Option to Utah Growers (Poster Board #180)

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Codling Moth (Cydia pomonella) is a serious pest of apple throughout the world and has been found wherever apples are grown. Control is generally achieved by setting out pheromone traps at first bloom, then tracking degree days after first catch. Pesticide sprays are applied around 250–300 degree-days. In Utah, setting a codling moth biofix from pheromone traps has become problematic due to inconsistent spring weather conditions, and higher use of mating disruption. In addition, an online decision-aid tool (Utah TRAPs) which includes 91 locations is offered to growers. Currently the biofix dates for each location must all be entered manually; automating this system would save time and resources. Research by Jones et al. [(2013) DOI 10.1002/ps.3519 (www.wileyonlinelibrary.com)] found that site-specific codling moth emergence (in degree days) is predictable using a formula based on latitude alone, or in combination with elevation for sites > 400 m in elevation. The study hypothesized that errors in setting the biofix with the formula timing were low, as it represented only a small percentage of the degree-day accumulations needed for predicting subsequent flight and egg hatch. This project objective is to introduce the “formula biofix” to Utah apple growers by demonstrating a low error rate in predicting codling moth phenology between the formula- and trap catch-based methods. Through season-long trapping and determination of first larval entry into fruit for first and second generations, we found that predictions for egg hatch and subsequent moth flight using the two biofix options varied by 0–3 days in 2016, and by 1–7 days in 2017. Our target was a variance of ≤ 5 days. The formula-based biofix (with a 1 Mar. start date) meets our goal for most locations in most years, and performs as well as the trap-catch biofix. The final phase of the project will be to continue with grower outreach, and in gauging grower confidence in switching to the formula biofix option.

Specified Source(s) of Funding: USDA Specialty Crops Block Grant

Characterizing Spray Penetration of a Novel Sprayer into Malus Domestica ‘Golden Delicious’ Apple Trees at a Commercial Orchard (Poster Board #181)

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An asterisk (*) following a name indicates the presenting author.
Novel, variable-rate spray technology was developed that can be retrofitted to existing airblast sprayers. The sprayer applies pesticides based on real-time scanning laser rangefinder measurements of plant presence, size, and density. The objective of this experiment was to evaluate spray coverage and deposit density at four application rates applied to Malus domestica ‘Golden Delicious’ apple trees from the newly developed technology. Uniform trees in two 408-ft long rows running in an East–West orientation were used for this study. Four pairs of trees, the 3rd, 15th, 25th, and 35th trees, across the driveway from one another were selected, and four clips for water sensitive cards (WSCs) were placed equidistant from one another within each canopy. Clips were attached to branches at increasing distances from the driveway at a height of 170 to 180 cm from the ground. One of four rates, 0.03, 0.05, 0.07, or 0.09 fl oz/ft², was randomly assigned to each pair of trees within the row so that all four rates were tested on each run. WSCs were placed in the clips, and the trees were sprayed with water. Rates were randomly re-assigned to trees, and a WSC was placed in each clip prior to each of the three subsequent runs. Cards were analyzed for coverage (%) and droplet density (deposits/cm²). There was an orientation effect on sprayer performance due to wind direction. Coverage was 24, 16, 10, and 3% greater for cards 1, 2, 3, and 4, respectively, on the North set of trees compared with the South set. In the North row of trees, card position 1 had 35% more coverage than card position 2 and had 47% and 209% greater coverage than card positions 3 and 4, respectively. Similarly, card position 1 in the South row of trees had 26% more coverage than card position 2 and had 30% and 159% greater coverage than card positions 3 and 4, respectively. For all rates, increasing distance between the sprayer and card position increased droplet density for trees on the North row, likely due to the heavier coverage on the North side causing droplets to coalesce on the cards in closest proximity to the sprayer. On the South row, droplet density was relatively consistent across the canopy at the 0.03 and 0.05 fl oz/ft² rates but increased with increasing distance from the sprayer at the higher two rates.

Allelopathic Effect of Horseradish Extract on Lettuce Germination and Growth

*(Poster Board #183)*

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Horseradish (Armoracia rusticana) is a root crop in the Brassicaceae family. Horseradish extract (HRE) contains many bioactive secondary metabolites such as glucosinolates. Sinigrin is the most common glucosinolate accounting for 80% of the HRE glucosinolate content. Sinigrin naturally undergoes hydrolysis to produce isothiocyanates such as allyl isothiocyanate (AITC) as a defense response. AITC can act as an herbicide, insecticide, fungicide, bactericide and more making it valuable for the agricultural industry. Because horseradish is generally utilized for its roots, the glucosinolate rich leaves are often discarded when they could be utilized. The aim of this study is to increase our understanding of the allelopathic effects of HRE for these agriculturally beneficial properties. Lettuce was chosen as an ideal organism for HRE treatment due to its high germination rate and biological reproducibility. Lettuce root length and root hair length were measured after 3 days of treatment with control, 1%, 2%, 4%, and 8% HRE w/v. The average root lengths respectively were 21.9 mm, 22.6 mm, 23.3 mm, 17.0 mm, 11.0 mm. Concentrations of HRE above 2% w/v were significant with all other concentrations. The average root hair lengths respectively were 1.30 mm, 1.27 mm, 0.76 mm, 0.69 mm, and 0.20 mm. All HRE treatments were significant excluding 1% w/v. Lettuce root length increased insignificantly with lower concentrations of HRE and then decreased significantly as the dose increased while root hair length decreased in a dose-dependent manner. H2O2 was quantified in lettuce treated with 1% w/v HRE at days 1 through 5 using ABTS and spectrophotometer reading at 414 nm. Control and treatment values at days 1–5 respectively were 2,759, 687.5, 376.2, 575.1, 217.3, and 4,100.8, 835.9, 386.7, 632.3, 239.6 μmol·g⁻¹ fresh weight. There was a significant difference in H2O2 concentration at day 1 though after there was no significance and there was a similar trend. Lettuce primary metabolite analysis was done on 36 metabolites using GC-MS and Metaboanalyst. Lettuce were grown for 2 days and then treated with 1% and 2% w/v HRE for 1 day and collected. Proline (Pro), valine (Val), and tryptophan (Trp) all increased significantly in a dose dependent manner with variable importance for projection (VIP) values of 0.46, 0.45, and 0.43, respectively. Trp is a precursor to IAA which can increase root growth via cell elongation at lower concentrations though inhibits growth at higher concentrations which was observed. Pro is the precursor to hydroxyproline which is an important component of extensin in the cell wall which causes mechanical wall stiffening associated with an oxidative burst. This was seen with increased H2O2 concentration in HRE treated lettuce at day 1 along with decreased root growth. Valine increases are likely due to feeding electrons to the mitochondria for increased demand and signaling.

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Changes in Ripeness Attributes of Peaches and Nectarines during Postharvest Storage

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Peaches and nectarines (Prunus persica L.) are a valued fresh-market crop world-wide. Since they are climacteric fruit (ripen after harvest), evaluating the postharvest potential of cultivars and breeding selections helps determine the feasibility of harvesting, shipping, and storing for commercial markets. The ripeness attributes (chlorophyll, fruit weight, flesh firmness, and composition) of 10 peach and nectarine genotypes from the University of Arkansas Fruit Research Station in Clarksville were evaluated at harvest (day 0) and after storage at 2°C on day 7 and 14. The five cultivars evaluated were ‘Amoore Sweet’, ‘Bowden’, ‘Bradley’, ‘Effie’, and ‘Souvenirs’, and the five selections were A-663 CN, A-794 CN, A-811 CN, A-819, and A-885. The fruit was hand harvested at tree ripeness (fruit ripened on the tree) and commercial ripeness (fruit picked to ripen during storage). Fruit was harvested based on chlorophyll A content of the fruit skin measured using a Delta Absorbance Meter. Tree-ripened fruit was harvested at chlorophyll below 0.25, whereas commercially-ripened fruit was harvested between 0.5 to 1.0. Chlorophyll, fruit weight, and firmness were evaluated at harvest and after storage in triplicate. After evaluation, fruit was frozen (-20°C) for compositional analysis (titratable acidity, pH, and soluble solids). At harvest, the fruit had ripeness ranges that included chlorophyll (0.04-0.86), weight (132-264 g), soluble solids (7.23-12.57%), pH (3.18-4.66), titratable acidity (0.16-1.21%), and firmness (6.92-35.72 N). The tree-ripened fruit at harvest tended to have lower chlorophyll (0.12), titratable acidity (0.55%), and firmness (11.51 N), but higher weight (205.9 g) and soluble solids (9.92%) as compared to commercially-ripened fruit. During storage of the commercially-ripened fruit, the chlorophyll and the weight decreased. In addition, the soluble solids increased from 9.13% at harvest to 11.08% at day 14, and titratable acidity had an inverse relationship with soluble solids. The firmness of the commercially-ripened fruit at harvest was 23.62 N, then slightly increased (26.22 N) at day 7, but decreased by day 14 (20.31 N). The titratable acidity and soluble solids reached the potential of tree-ripened fruit after 7 days of storage. A-794 CN and Effie had the highest soluble solids, A-794 CN had the highest titratable acidity, and ‘Amoore Sweet’ had the highest firmness. However, some ripeness attributes of the commercially-ripened fruit, such as chlorophyll and weight, were not achieved as compared to the tree-ripened fruit. When evaluating fresh-market peaches and nectarines, the ripeness attributes vary by genotype and maturity of the fruit at harvest.

Impression of Consumer Sensory and Composition Attributes of Fresh-market Blackberries

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Blackberries are grown around the world as a specialty crop for commercial fresh markets and processing. Three Arkansas-grown fresh-market blackberry genotypes (two cultivars and one selection) were hand harvested at the shiny-black stage of ripeness and evaluated for consumer sensory and compositional attributes at the University of Arkansas Food Science Department, Fayetteville. ‘Natchez’ and ‘Ouachita’ were harvested from a commercial grower in Fayetteville, and A-2418 was harvested from the University of Arkansas Fruit Research Station in Clarksville. The compositional attributes of the blackberries at harvest were within an acceptable range for commercial markets (soluble solids = 8.2 to 11.9%, pH = 2.8–3.2, titratable acidity = 1.1 to 1.3%, and soluble solids to titratable acidity ratio = 6.3–10.9). In terms of soluble solids to titratable acidity ratio (the balance of perceived sweetness or sourness), ‘Ouachita’ had the highest ratio of 10.9 followed by ‘Natchez’ with a ratio of 8.9, and A-2418 with a ratio of 6.3. A consumer sensory panel (n = 80) evaluated fresh-market blackberry attributes using a 9-point hedonic scale for overall impression, overall flavor, sweetness, and sourness and a 5-point Just-about-Right (JAR) scale for sweetness and sourness. In addition, the consumers ranked the blackberries in order of overall liking from most to least. In regards to overall impression, overall flavor, and sweetness, ‘Natchez’ was scored highest followed by ‘Ouachita’ and A-2418. However, there were no differences between the three genotypes for sourness. In terms of JAR, consumers scored A-2418 the highest for “not sweet” and “too sour”, whereas ‘Natchez’ was highest in “JAR” scores for sweetness and sourness. ‘Natchez’ was significantly liked over the other genotypes as it was ranked first for 53% of the consumers as compared to 26% for A-2418 and 21% for ‘Ouachita’. More investigation would be beneficial to determine the relationship between blackberry liking and compositional attributes, but these results provide valuable information for future blackberry breeding.

Influence of Pecan Shell Mulch on Rabbits-eye Blueberry Establishment

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Pecan (Carya illinoinensis) shells are an inevitable byproduct of the pecan industry that is, in most cases, treated as waste. Repurposing this shell waste as mulch could be an opportunity for pecan growers to retool their waste and make it a value added

*presenting author.
resource. The shell waste produced could be used to supply the rabbiteye blueberry (Vaccinium virgatum) with an alternative to pine bark mulch. This study was conducted to determine the effect of pecan shell mulch on rabbiteye blueberry establishment. An on-farm field study of ‘Krever’ rabbiteye blueberries was installed in February 2016 to determine the efficacy of seven treatments: “fresh” milled pecan shells (2015), “aged” milled pecan shells (2014), and the industry standard pine bark mini nuggets at 7.5 cm and 15 cm depths with a bare ground treatment with no weed control except mowing (control). Data were collected on weed density, soil moisture content (SMC), and plant size index (PSI). Weed density was highest in the control, with “fresh” shells and pine bark being comparable. Soil moisture content (SMC) was highest in the “aged” shells, with the fresh shells at the 7.5 cm depth being comparable to the pine bark mini nuggets. All mulch treatments had a higher SMC than the control. Plant size index (PSI) was reduced in the control and was similar in all of the mulch treatments. The results from this study indicate that pecan shell mulch could provide comparable weed control, moisture retention, and plant growth to the industry standard, pine bark mini nuggets, through the first two years of establishment.

**Role of Antioxidants on the Incidence of White Drupelet Disorder in Blackberry Cultivars**

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White drupelet disorder in blackberries is an enigmatic physiological phenomenon that is not tolerated by growers who rely on shipping to earn profits. Abiotic conditions such as ultraviolet (UV) light and drastic changes in temperature and humidity are the primary suspected causes that trigger white drupelet occurrence in developing fruits. It is suspected that this overexposure of photon energy driving the transfer of ‘excited’ electrons between the P680 reaction center of photosystem II and the primary electron carrier intermediate, pheophytin, is causing bleaching of chlorophyll within individual drupelets. Photosynthetic capacities of fifteen cultivars grown in Upstate South Carolina were measured during the harvest season and light response curves for each cultivar were plotted. Assays to evaluate antioxidant enzyme activity in preserved leaf samples included measuring amounts of malondialdehyde (MDA) (representative of lipid peroxidation damage in cell membranes) and in vitro activity of extracted ascorbate peroxidase (APX) reacting with prepared H2O2 to correspond with the quantitative and qualitative characteristics assigned to evaluated cultivars. Measurements revealed maximized photosynthetic capacities that categorize cultivars into quantitative high performers, medium performers, and low performers in addition to qualitative characterization of having white drupelets (Wd) or no white drupelets (NWd) occurrence. For each quantitative category, there were both cultivars with Wd and NWd, which supports the idea that UV is not the only factor involved in inducing white drupelets. There were no differences in MDA concentrations among cultivars, regardless of quantitative and/or qualitative characterization, and APX activity is still being assessed. Nevertheless, preliminary results using representative leaf samples has so far proven to be inconclusive and future works using harvested fruits from experimental cultivars will potentially hold stronger promise for discovering the physiological mechanisms behind occurrence of white drupelet disorder.

**Norman F. Childers**  
MS Graduate Student Paper Competition

**A Comparison of Nutrient Film Technique (NFT), Deep Flow Technique (DFT) and Shallow Aggregate Ebb and Flood (SAEF) Systems for Basil Production in Controlled Environments**

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In previous experiments conducted at the University of Arkansas, a novel technique was developed to allow ornamental greenhouse growers to adapt their existing ebb and flow benches to produce hydroponic lettuce. This shallow aggregate ebb and flood (SAEF) system was determined to be as effective as the traditional NFT and DFT hydroponic systems. This experiment was conducted to compare the NFT, DFT and SAEF systems for the production of fresh herbs. Four types of basil (Genovese, Sweet Thai, Lemon, and Cinnamon) were planted in rockwool sheets in propagation traps and then transferred to the three different systems at the growth stage of two true leaves. The basil was then harvested three weeks after being transplanted from the propagation trays. This experiment evaluated each of the types of basil within the three systems (NFT, DFT, and SAEF), in three blocks across time. An analysis of variance (ANOVA) was conducted to determine if there were significant differences in fresh weight, leaf area, SPAD or average internode length among the systems. There were no significant differences among systems except for in SPAD lemon basil. A least significant difference (LSD) mean separation test was conducted to determine specific differences between treatments. Difference was found among the systems. There were no significant differences among systems for chilling stress. Other than this SPAD reading in lemon basil, there was not a significant difference between systems.

**Effects of Cucurbita Rootstocks on Tolerance of Grafted Seedless Watermelon Seedlings to Chilling Stress**

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While grafting with Cucurbita rootstocks can help effectively manage Fusarium wilt of seedless watermelon (Citrullus lanatus), cold-tolerant rootstocks may also be selected to assist
early planting and harvest for integrated use of grafting in seedless watermelon production towards improved economic viability. In this pilot study, seedless watermelon ‘Fascination’ was grafted onto eight Cucurbita rootstocks to determine the response of grafted seedlings to chilling stress in comparison with non-grafted and self-grafted plants. Plants were exposed to chilling temperature at 9 °C from 8:00 pm to 7:00 am for 6 days via a walk-in cooler to mimic early season planting of seedless watermelons. Plants grown in the greenhouse without chilling exposure were also included as controls. Two experiments were conducted using 2-true-leaf and 5-true-leaf seedlings, respectively. A completely random design was used with 10 plants in each of the grafting and chilling treatment combinations. Following the 6-day chilling treatment, stem diameter, leaf number, vine length, and relative chlorophyll content (SPAD) were measured. In addition, destructive measurements of leaf area and shoot and root dry biomass as well as root characteristics were performed after 7 days of recovery by growing plants in the greenhouse without chilling exposure. Overall, the chilling treatment resulted in stunted growth of seedlings. Significant differences were observed between grafted and non-grafted plants and among plants grafted with different rootstocks. At the end of the recovery period, some rootstocks led to improved plant growth and root development as compared with non-grafted and self-grafted plants. This preliminary study demonstrated the potential of using selected Cucurbita rootstocks to improve cold tolerance of seedless watermelon seedlings.

**Evaluation of a New Herbicide for Sensitive Herbaceous Ornamental Crops**

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There is a need for preemergence herbicides in the container nursery industry due to the high cost of hand weeding, but few preemergence herbicides are labeled for sensitive herbaceous ornamental crops. Currently, Snapshot® (isoxaben + trifluralin) is the only granular formulated preemergence herbicide labeled for many sensitive herbaceous ornamental crops. Fortress® (isoxaben + dithiopyr) is a new granular preemergence herbicide made by OHP, Inc. for use on sensitive herbaceous ornamental plants. In this experiment, four species of ornamental herbaceous crops in #1 containers were treated with Fortress® at 150, 300, and 600 lb/A, a spray combination of Gallery® (isoxaben) and Dimension® (dithiopyr) at 0.75 + 0.38 lb/A active ingredient (a.i.), and Snapshot® (isoxaben + trifluralin) at 150 lb/A. Also, #1 containers filled with amended 6:1 pine bark:sand substrate were treated with Fortress at 100, 150, and 200 lb/A, Gallery® (isoxaben) and Dimension® (dithiopyr) at 0.75 + 0.38 lbs/A a.i., and Snapshot® (isoxaben + trifluralin) at 150 lb/A and then overseeded with 25 seeds of either oxalis, bittercress, eclipta, phyllanthus, spurge, or crabgrass. Fortress® had no effect on size index and caused no significant phytotoxicity of crops tested. Fortress® had excellent control of bittercress and oxalis 60 DAT, and good control of eclipta 30 and 60 DAT. It provided good control of spurge 30 DAT, but almost none 90 DAT. Fortress® provided poor phyllanthus control 60 DAT while Snapshot® provided excellent control. All herbicide treatments provided excellent crabgrass control 90 DAT.

**Fine Mapping of Egusi Trait Locus (eg) In Watermelon using SNP Markers**

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A distinct type of watermelon called Egusi watermelon (Citrullus mucosospemus) is cultivated in many West African countries for its proteinous and lipid rich edible seeds. These watermelons are the closest relative of sweet watermelon (C. lanatus), but unlike sweet watermelon they have bland white flesh and seeds with a typical thick mucilaginous seed coat. This unique seed coat, called egusi type seed coat, is genetically controlled by a single recessive gene, eg, mapped from 6.75 Mb to 9.58 Mb on chromosome 6 of the C. lanatus genome. This region is 2.9 Mb wide and contains 170 candidate genes. However, due to lack of markers in this region, further fine mapping has not been possible. In this study, we employed QTL-seq to remap the egusi locus and identify SNP markers for fine mapping in the Strain II (PI 169233) × egusi (PI 560023) F2 population previously used to map the locus. QTL-seq identified a significant locus associated with the egusi trait from 5.25 Mb to 7.85 Mb on chromosome 6, partially overlapping the previously mapped locus. Competitive Allele Specific PCR (KASP) assays were designed for 16 SNPs in the eg region and tested on the population. The fine mapping narrowed the locus to a 197.16 Kb region between KASP marker UGA6_6829416_C and UGA6_7026576_C. This region contains 19 candidate genes. In future, functional analysis of these candidate genes will be conducted to identify the gene responsible for the egusi phenotype.

**Influence of Compost Application Method on Soil Quality and Plant Growth in Organic Spinach Production**

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Two organic spinach trials were conducted in Citra, FL to determine the effects of compost application method on soil quality properties, crop establishment, and plant growth in open field and high tunnel production systems. The compost application methods included: 1) broadcasting and tilling compost into the soil at 15 cm depth; and 2) banding compost in 5 cm deep furrows in the seeding beds. Spinach was direct seeded in both trials, which were arranged in a split-split plot design with 3 replications and the production system (open field and high tunnel) as the whole plot factor. In the first trial (Nov. 2016
A - 54x20

At GSP, 8 of 24 plants were infested, with CMBS plants found south-center to the north and randomly throughout study plants. The first CMBS were found in year three at the GSP (4 had 11 crape myrtles, the closest 17 m from study plantings. No PSC had one crape myrtle, 35 m from study plantings, and GSP October). At study initiation, the BBF had no crape myrtles, the closest 17 m from study plantings. Plants were maintained with minimal input, with no fertilization, pH 5.2), and the Greenville Sports Park (GSP) (clay, pH 8.2).

Crape myrtles are an important landscape plant in the southern United States. In 2004, a new pest, the crape myrtle bark scale (CMBS), was identified in North-central Texas. The pest rapidly causes a decline in plant quality and, like many scale, can prove to be difficult to control. Currently, evidence suggests that crawlers remain near their parent, but may also be spread by wind, animals, and humans. A study was conducted to evaluate the likelihood of CMBS infecting new crape myrtles when planted in exposed conditions or near other crape myrtles. Researchers used 24 crape myrtles planted at three locations with varied soil types, the A&M-Commerce Plant Science Center (PSC) (silt loam, pH 7.1), the A&M–Commerce Blueberry Farm (BBF) (loamy sand, pH 5.2), and the Greenville Sports Park (GSP) (clay, pH 8.2).

Across both trials, the furrowed treatment increased levels of soil K, Mg, Ca, and CEC by 450%, 122%, 77%, and 77% on average, respectively, in contrast to the tilled treatments. Soil organic matter and total carbon contents were higher in the furrowed treatment by approximately 69% and 21%, respectively. Soil bulk density was reduced by about 28% in the top 5 cm in the furrowed treatment compared to the tilled treatment; however, significant differences were not observed at 5–10 cm or 10–15 cm. The tilled treatment did not differ significantly from the no compost control in soil quality properties measured. Spinach germination, plant establishment, and crop vigor were all improved with furrowed compost. Results from this study suggested that compost application method modification may help enhance organic spinach performance in both open field and high tunnel systems.

**Location Effects on Crape Myrtle Bark Scale Incidence**

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Crape myrtles are an important landscape plant in the southern United States. In 2004, a new pest, the crape myrtle bark scale (CMBS), was identified in North-central Texas. The pest rapidly causes a decline in plant quality and, like many scale, can prove to be difficult to control. Currently, evidence suggests that crawlers remain near their parent, but may also be spread by wind, animals, and humans. A study was conducted to evaluate the likelihood of CMBS infecting new crape myrtles when planted in exposed conditions or near other crape myrtles. Researchers used 24 crape myrtles planted at three locations with varied soil types, the A&M-Commerce Plant Science Center (PSC) (silt loam, pH 7.1), the A&M–Commerce Blueberry Farm (BBF) (loamy sand, pH 5.2), and the Greenville Sports Park (GSP) (clay, pH 8.2).

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**Occurrence and Possible Causes of Peach Skin Streaking**

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Streaking is a skin discoloration in red blush varieties of peaches, characterized by club-shaped streaks, lacking red color. Symptoms vary in intensity ranging from faint light streaks to pronounced streaks and necrotic tissue. The current hypothesis suggests that causal agents are accumulated in the atmosphere during periods of drought and then brought down with light rain events. Occurrence and severity data were obtained from a commercial orchard and Clemson’s Musser Fruit Research Center in 2017 growing season. Trees were examined for streaking symptoms starting four weeks prior to harvest in weekly intervals. On ‘Julyprince’ (Clemson) 50% of fruit examined showed symptoms, while on ‘Scarletprince’ (Commercial grower) 6 to 25% of fruit examined displayed streaks. Incidence was also recorded with relation to fruit positioning within the canopy (top, bottom, inside, outside) which for ‘Julyprince’ was 43%, 59%, 27%, 27% respectively. Data from one location with ‘Scarletprince’ suggested a greater incidence on fruit on the top and outside. Precipitation and pH of rainwater were collected for twelve locations at the commercial orchard for six varieties with ripening periods between mid-June and mid-August. Both precipitation and pH differed greatly between sampling dates and locations. Rain samples were analyzed for total and free chlorine as well as chloride dioxide. Although levels of free chlorine and chloride dioxide were not within the detectable range of 0.01–6 mg/L for Cl2 and 0.05–11 mg/L for ClO2, more work needs to be done to determine their concentrations at the time of precipitation. Acidic and ozonated solutions were applied to Cresthaven and August Lady prior to harvest but none of the treatments reproduced the symptoms.

**Physicochemical and Sensory Ripeness Attributes of Arkansas-grown Peaches and Nectarines**

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Understanding how consumer perception is related to physicochemical attributes helps identify harvest and ripeness parameters of peaches and nectarines (Prunus persica L.). Six peach and nectarine cultivars (‘Amoore Sweet’, ‘Bowden’, ‘Effie’, ‘Loring’, ‘Souvenirs’, and ‘White River’) and three advanced near the infested planting at GSP were also infected. The BBF had the highest wind protection and the least human or animal contact. While it does appear that proximity to infested plants increases the likelihood of infection, we found no evidence of a dispersal mechanism or reason for initial infestation.
breeding selections (A-827, A-850, and A-865) were harvested at optimum ripeness from the University of Arkansas System Division of Agriculture Fruit Breeding Program in Clarksville. The physicochemical and sensory attributes of the genotypes were evaluated. The range of physiochemical attributes of the genotypes at harvest were a fruit weight of 134.4–330.2 g, soluble solids of 7.5 to 14.7%, pH of 3.3–4.8, titratable acidity of 0.2 to 1.1%, and firmness of 7.8–35.8 N. Overall, A-865 had the lowest pH (3.3) and the highest firmness (35.8 N), soluble solids (14.7%), and titratable acidity (1.1%). A-850 had the lowest titratable acidity (0.2%) while ‘Loring’ had the lowest soluble solids (7.5%). A trained descriptive sensory panel (n = 10) evaluated the peaches for basic tastes (sweet, sour, and bitter), aromatics (overall aromatics and green/unripe), and texture (flesh hardness, fibrousness between teeth, and moisture release) attributes using a 15-point scale (0 = less of the attribute and 15 = more). The panelists did not detect differences in sweetness, bitterness, or overall aromatics between the genotypes, but did detect differences in sourness, green/unripe, flesh hardness, fibrousness between the teeth, and moisture release. ‘Bowden’ was the sourest and A-850 was the least sour. ‘Souvenir’ had the hardest flesh and ‘Loring’ the least. There were no correlations between basic tastes and soluble solids or titratable acidity, but sourness was correlated with pH \( r = -0.82 \) and titratable acidity \( r = 0.89 \). Overall aromatic impact was correlated to titratable acidity \( r = 0.68 \) and fruit firmness \( r = 0.75 \). The highest correlations between physicochemical and sensory attributes were in the traits related to fruit firmness. Fruit firmness was also correlated with sourness \( r = 0.68 \), flesh hardness \( r = 0.70 \), green/unripe aromatics \( r = 0.72 \), fibrousness between teeth \( r = 0.84 \), and moisture release \( r = -0.77 \). The associations found between texture and sourness attributes further advances understanding of how consumers perceive ripeness of peaches/nectarines.

Preharvest and Postharvest Effects on Internal Necrosis Incidence and Severity In ‘Covington’ Sweetpotato

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Internal Necrosis (IN) has been characterized as a physiological disorder in certain sweetpotato clones. ‘Covington’ is the main sweetpotato grown in North Carolina. The IN symptoms manifest themselves as brown to black areas in the flesh at the proximal end of the root. Preliminary studies have associated the occurrence of IN when roots were exposed to fertilizer with high chlorine levels and when foliage was mowed prior to harvest and exposed to recommended curing temperatures. The goal of our research was to evaluate if the abiotic stress created with a high chlorine fertilizer and mowing in combination with high curing temperatures and duration affected IN occurrence and severity. Three field studies replicated four times in three different field locations and dates were conducted. Application of a high chlorine [muriate of potash (MP)] versus minimal chlorine [potassium sulfate (PS)] level fertilizers and mowing or not prior to harvest (10–14 days) were the four preharvest treatments evaluated. For the postharvest treatments, 30 roots were obtained from each of the preharvest treatments and placed in 75 °F, 82 °F or NO CURE (58 °F, check treatment) rooms for different curing durations (1/2, 1, 2, 3, and 5 weeks). Samples were cut approximately 2 months after harvest and IN incidence and severity were recorded. Each study was analyzed comparing the significance of the main effects (preharvest & postharvest) and its interactions using PROC GLM at the 5% level of significance. Generally, incidence of IN in the three studies was relatively low (<20%). Low levels of IN (5% or less) were recorded in all studies when roots were exposed to NO CURING or cured for 1/2 week. After 1 week at 75 °F or 82 °F, IN increased 2 to 4%. After 2 weeks, IN levels increased to at least 10%, with a maximum of 15% after 3 weeks. IN response to temperature set points were significantly different; the incidence was approximately 7% when cured at 75 °F and increased to 12% IN at 82 °F. Interactions between temperature and mowing showed significant differences in one location where the “not mowed” under 82 °F had higher IN (11%) than the mowed (6%). Finally, in one location, roots exposed to MP (high chlorine) resulted in higher levels of IN when placed at 82 °F (10%) compared to PS (low chlorine fertilizer, 7%). Exposure to higher temperatures (82 °F versus 75 °F) consistently resulted in higher IN incidence and severity. The lack of curing or curing for less than one week at 75 °F rather than at a higher temperature may be a management tool for the sweetpotato industry to help reduce incidence and severity of IN.

Preliminary Assessment of Selected Hybrid Bunch Grape Rootstocks

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An experimental vineyard was established at the Chilton Research and Extension Center (CREC), Clanton, Alabama in 2014 with the goal to determine the best-suited rootstocks for sustainable hybrid bunch grape production in Alabama. Own-rooted (OWR) and grafted ‘Norton’ and ‘Chardonel’ vines were studied to determine the rootstock effects on vine vigor, productivity, and fruit quality. The vines were planted in a RCBD comprised of seven replications, with two experimental vines per rootstock-scion combination per replication. ‘Norton’ plants were grafted on ‘Kober 5BB’, ‘Teleki 5C’, and ‘Chardonel’ vines were grafted on ‘Paulsen 1103’. Our preliminary results suggest that OWR ‘Norton’ vines grew vigorously and produced the highest pruning weight of 0.8 kg/vine. Total yield per vine varied from 2.7 to 9.1 kg/vine with OWR and grafted ‘Chardonel’ vines producing higher yields than ‘Norton’ vines. No rootstock effect was found on vine total yield. ‘Norton’ grafted on ‘5BB’ had the highest number (72.8) of clusters per vine, while OWR ‘Chardonel’ and OWR ‘Norton’ had the fewest clusters. OWR ‘Norton’ berries had the highest soluble solid content (SSC), while ‘Chardonel’ vines had lower sugars...
The vertical shoot positioned (VSP) training system is a single canopy system commonly used for wine grape (Vitis vinifera) production throughout the world. The VSP system, however, confines leaf area and fruit production between trellis catch wires that are spaced no more than 15 cm apart. The VSP system thus restricts exposed leaf area and fruit production. This study investigated the effects of retrofitting an already-established VSP trellis in a Petit Manseng vineyard by comparing 1) a sprawl and tight VSP canopy, and 2) using cane or double bilateral cane pruning as compared to spur pruning. It was hypothesized that the sprawled canopy would hasten soluble solids accumulation and that double bilateral cane pruning would increase crop yield. Canopy training had no effect on crop yield. Double bilateral cane pruning increased crop yield by an average of 44% when compared to spur and cane pruning. Juice soluble solids at harvest was not affected by canopy training nor pruning treatment. Juice titratable acidity at harvest was greater in the sprawled when compared to tight canopy, and double bilateral cane when compared to spur pruning. Preliminary results suggest that double bilateral cane pruning can improve crop yield per vineyard acre and can thus be a fiscally-rewarding practice.

Table Stock Potato Cultivar Response to Preharvest Vine Desiccation Timing

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Potato skinning is the removal of the outer layer of epidermal cells on the tuber as the result of a poorly developed skin that rubs off easily during harvest and handling operation (e.g., packaging, cleaning, and classification). Preharvest vine desiccation artificially promotes tuber maturation and reduces skinning injuries. Vine desiccation management can potentially mitigate quantitative and qualitative losses associated with under-mature tubers such as dehydration, infection by pathogenic microorganisms, and external defects. The study objective was evaluate the effect of desiccation application timing on yield, internal quality, degree of skinning, peel resistance, and post-harvest quality maintenance of potato cultivars. A field experiment was conducted during spring of 2017 in Hastings, FL, with a split-plot randomized complete block design. Main plot was potato cultivar: ‘Soraya’, ‘Red LaSoda’, and ‘Peter Wilcox’. Subplots were diquat application timing: single application [0.56 kg·ha⁻¹ active ingredient (a.i.)] at 7, 14, or 21 days before harvest (DBH), and split applications (0.28 kg·ha⁻¹ a.i.) at 7 + 14, 7 + 21, and 14 + 21 DBH. Results indicated vine desiccation practice has no negative effect on tuber yield. A single application at 7 DBH leads to plant stress stimuli and development of vascular discoloration. There was a significant interaction between cultivar and application timing on degree of skinning. Skinning severity was greatly reduced in treated tubers. Red LaSoda and Peter Wilcox tubers treated with a single application at 7 DBH were classified as badly skinned. Peter Wilcox had higher skinning severity than Soraya and Red LaSoda. Application timing was not significant for peel resistance, firmness, and fresh weight loss. Tuber samples before harvest had an increase in peel resistance from 21 DBH to harvest day. The cumulative fresh weight loss of Peter Wilcox after 21 days of storage was significantly higher than Soraya and Red LaSoda. Desiccate vines gradually, 14 or 14 + 7 DBH, for the complete kill can potentially reduce skinning injuries at harvest while decrease weight loss during storage.

The Effects of Grafting on Disease Incidence of Fusarium oxysporum f. sp niveum races 1 and 2 in Watermelon

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Fusarium oxysporum f. sp. Niveum (FON) races 1 and 2, causal agents of Fusarium wilt, have long caused problems in watermelon (Citrullus lanatus) production operations. Grafting popular scion onto resistant or tolerant rootstock has been introduced as a successful way of managing disease. The Watermelon var. Sugar Baby is a diploid mini watermelon variety and is severely susceptible to infection by FON races 1 and 2. Previous greenhouse and field studies suggested the physical process of grafting inherently gives some level of tolerance to infection by FON races 1 and 2 so this was tested using ‘Sugar Baby’ scion and ‘Carnivor’ (Cucurbita maxima × Cucurbita moschata) and ‘Bulldog’ (Citrullus amarus) rootstocks. Four treatments were tested to see the effect grafting has on the infection by FON races 1 and 2 on a susceptible watermelon scion (‘Sugar Baby’). ‘Sugar Baby’ non-grafted was used as a control. ‘Sugar Baby’ × ‘Carnivor’ and ‘Sugar Baby’ × ‘Bulldog’ both had survival rates of approximately 100% for both pathogen race treatments with no significant difference between. ‘Sugar Baby’ × ‘Sugar Baby’ had a 23% survival rate when compared to 0% for ‘Sugar Baby’ non-grafted for FON race 1. ‘Sugar Baby’ × ‘Sugar Baby’ had a 34% survival when compared to 17% survival of ‘Sugar Baby’ non-grafted for FON race 2. This observation provides us with more evidence to support the hypothesis; the physical process of grafting interferes with infection of FON races 1 and 2.

Retrofitting Vertically Shoot-positioned Petit Manseng to Improve Vineyard Crop Yield

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The vertical shoot positioned (VSP) training system is a single canopy system commonly used for wine grape (Vitis vinifera) production throughout the world. The VSP system, however, confines leaf area and fruit production between trellis catch wires that are spaced no more than 15 cm apart. The VSP system thus restricts exposed leaf area and fruit production. This study investigated the effects of retrofitting an already-established VSP trellis in a Petit Manseng vineyard by comparing 1) a sprawl and tight VSP canopy, and 2) using cane or double bilateral cane pruning as compared to spur pruning. It was hypothesized that the sprawled canopy would hasten soluble solids accumulation and that double bilateral cane pruning would increase crop yield. Canopy training had no effect on crop yield. Double bilateral cane pruning increased crop yield by an average of 44% when compared to spur and cane pruning. Juice soluble solids at harvest was not affected by canopy training nor pruning treatment. Juice titratable acidity at harvest was greater in the sprawled when compared to tight canopy, and double bilateral cane when compared to spur pruning. Preliminary results suggest that double bilateral cane pruning can improve crop yield per vineyard acre and can thus be a fiscally-rewarding practice.
The Impact of Daily Light Integral Supplements on Biomass and Nutrient Accumulation in Hydroponically Grown Genovese Pesto Basil

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Light quantity, quality, and duration are three primary factors that impact plant growth and development. Light emitting diodes (LEDs) have the ability to manipulate each of these parameters and allow commercial growers to optimize biomass yield and plant quality. Many studies have evaluated the impact of spectral quality and minimum daily light integral (DLI) requirements for a variety of specialty crops, but an in-depth efficacy comparison of progressive DLIs using various supplemental lighting sources is needed in order to optimize quality and biomass yield of high-value specialty crops during unfavorable growing seasons. The objective of this study was to determine the impact of incremental DLI supplements on greenhouse hydroponic basil (Ocimum basilicum var. Genovese) production using broad spectrum HPS lamps and blue (B)/red (R) narrowband wavelengths from LED lighting systems. Overall edible biomass and nutrient accumulation were evaluated. A total of nine lighting treatments were used: one non-supplemented natural light control, two HPS treatments with DLIs as 12 h and 24 h, and six 20B/80R LED treatments with progressive DLIs as 3 h, 6 h, 9 h, 12 h, 18 h, and 24 h. Each supplemental lighting treatment provided 100 µmolm⁻²sec⁻¹. The DLI of the natural light control averaged 9.5 mol·m⁻²·d⁻¹ during the growth period (ranging from 4 to 18 mol·m⁻²·d⁻¹). Relative humidity averaged 50%, with day temperatures averaging 29.4 °C and night temperatures averaging 23.8 °C. All treatments were harvested 45 d after seeding. Edible biomass and nutrient accumulation were significantly impacted by supplemental lighting treatments and growing season. The 12 h HPS treatment had the highest total biomass accumulation, both in fresh (FM) and dry biomass (DM); the 9 h LED treatment produced the lowest FM and DM averages across all seasons. The 18 h LED treatment produced the highest FM and DM of any other LED treatment, but was not statistically separate from the optimal HPS treatment. Mineral analysis revealed that both macro and micronutrient accumulation was impacted by various light treatments. This experiment shows that the spectral quality and DLI of supplemental lighting sources have varying levels of impact basil metabolism. LED and HPS lighting systems both have merits for improving biomass accumulation and nutrient uptake in hydroponically grown basil, but should be investigated further to determine optimal lighting types and practices for a variety of high-value specialty crops.

Unlocking the Genetic Code of Brown Rot Tolerance in Peach

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Brown rot, caused by Monilinia spp., is an important economic disease in peach that can cause significant yield losses by affecting both blossoms and fruits. Although some degree of tolerance has been detected in stone fruit (peach and almond) understanding the genetics behind resistance/tolerance to brown rot is still lacking. To this day few regions in peach genome associated with brown rot response in fruit skin and flesh have been detected. The limited knowledge about peach fruit response to brown rot infection suggests polygenic nature of brown rot tolerance. More information is needed to enable translation and application in breeding programs. Several sources of resistance have been identified and used within RosBREED project (www.rosbreed.org) to build a foundation for understanding the genetics behind the peach fruit response to brown rot. In this study, pedigree based material, with ‘Bolina’ and ‘Contender’ sources of tolerance, was phenotyped across two years (2015 & 2016), and genotyped using newly developed 16K peach SNP array. Association mapping, using GModel2, revealed total of 32 SNPs (P<1E-07) significantly associated with brown rot response in either peach fruit skin (21) and/or flesh (12) across whole genome. Detailed analysis of the haplotypes in the brown rot associated regions on chromosomes 5 and 8, revealed 9 haplotypes each with different brown rot response in peach fruit skin and flesh. Absence of haplotype 3 on chromosome 5 and haplotype 6 on chromosome 8 significantly reduced brown rot disease severity index in fruit skin and flesh, respectively. Candidate gene analyses within the haplotype regions identified genes associated with disease resistance and/or plant defense mechanism. The implications of this research for breeding and further strategies to unlock the genetic code of brown rot tolerance in peach will be discussed.

Warren S. Barham
PhD Graduate Student

Association Mapping for Iron Deficiency Chlorosis in Worldwide Cowpea

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Cowpea (Vigna unguiculata L.) is a legume consumed for its high protein content. It provides nutrient-dense food opportunities for human consumption. Iron Deficiency Chlorosis (IDC) has shown a problem for cowpea as yellowing of the leaves and reduced plant growth, thus reducing yield potential. Use of IDC tolerant cowpea cultivars is an efficient method to reduce the damage. The objectives of this study were to conduct a population structure analysis, to carry out an association mapping study, and to identify SNP markers associated with IDC tolerance
in cowpea. A total of 353 cowpea accessions were evaluated for tolerance/susceptibility to low soluble iron conditions on higher pH soils. A total of 1,006 SNP markers postulated from Genotyping-By-Sequencing (GBS) were used after filtering for population structure and association analysis studies. Results revealed that: 1) a substantial variability in degree of tolerance to low soluble iron conditions was found among the cowpea accessions; 2) delta K peak was identified at K equal to 2, indicating two subpopulations within the cowpea accessions tested for adaptation to IDC; and 3) nine SNP markers, C35081162_3130, Scaffold16136_2033, Scaffold1764_4741, Scaffold18262_4480, Scaffold30165_15499, Scaffold47194_5530, Scaffold73235_6677, Scaffold77932_9959, and Scaffold86559_7193, were significantly associated with IDC tolerance in cowpea. These results can be used as tools to select cowpea genotypes in low soluble iron condition with IDC tolerance.

**Determining Irrigation Water Requirements for Peach Trees In Humid Climate**

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Irrigation water must be supplied to fruit trees to reach maximum yield in Florida due to low water holding capacity in sandy soils and erratic rainfall distribution. Florida’s agricultural industry is moving to non-traditional crops such as peaches that have been normally grown in northern latitudes. Determination of peach tree water uptake under humid climate is crucial to provide guidelines for proper irrigation management. The objectives of this study were to estimate adult peach trees daily evapotranspiration (ETc) and to estimate crop coefficient (Kc) of an adult peach tree. Peach trees ‘Tropic beauty × Flordaguard’ were evaluated for water uptake and evapotranspiration for 12 months. Daily ETc ranged from 0.85 during dormancy to 3.39 mm/day during fruit development, the cumulative ETc during the 12-month period was 713 mm/year, the estimated Kc ranged from 0.42–0.80. The estimation of daily ETc and Kc provides growers with the information needed for more precise determination of peach irrigation water requirements year round. This information can help to prevent water stress that can lead to reduction of fruit yield and excess irrigation during dormancy when tree water uptake is lower.

**Hollow Heart Formation In Grafted and Non-Graded Watermelon**

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Watermelon, a fruit of great economic importance, has an annual production of 8.52 million mt. Hollow heart (HH) known as an internal crack develops in the center of the fruit. Proper pollination plays a crucial role in HH development, triploid cultivars and less dense cultivars are more prone to HH; effects of rootstock are unknown. Experimental objectives were to limit the amount of viable pollen and study HH formation in grafted and non-grafted watermelon. Liberty, prone to HH, was the scion and treatments were no graft (control), grafted onto Carnivore and Kazako (Interspecific hybrid rootstock (rs), C. moschata × C. maxima), and Emphasis (Lageneria siceraria, bottle gourd rs). Transplants were planted in Clayton NC, with diploid pollinizers (SP-6) planted on four rows at 6, 9, and 12 m in-row-spacing (three blocks/treatment row). Longitudinal cuts were made after weighing and fruit rated for HH incidence and void airspace. Firmness was measured with a FDX penetrometer with 0.8 cm diam. probe in heart and interlocular flesh tissue spaces. Heart tissue was saved for compositional and cell size assays. Pollenizer distance did not affect HH incidence or severity; HH was higher in non-grafted or Emphasis rs. Flesh firmness was increased by 1 N in interspecific rs and fruit without HH. The soluble solids content (%) was lowest in fruit from ‘Carnivore’ or fruit with HH. Sugar content was strongly and positively correlated to pH. Fruit with HH and from Lageneria rs were higher in pH. Incidence of HH or graft treatment had no effect on fruit weight, lycopene, citrulline, or arginine content. Confocal micrographs were obtained to count the number and size (μm²) of cells in fruit rated no, moderate, and severe HH. At least 750 cells were measured in fruit using ImageJ software (public domain). The number of cells were not affected by grafts or HH severity, the average surface area was largest for Emphasis fruit, with cell volume at 110,805 μm³ (P < 0.0001). Fruit with moderate HH also had larger cell volume (102,873 μm³). Limiting the number of pollinizers induced HH. Interspecific hybrid rs increased watermelon tissue firmness, cell density and decreased HH. Fruit were more susceptible to HH when firmness/cell density were lower. Results show HH can be field induced by using susceptible cultivars with limited pollen, or reduced by using certain rs.

**Testing Irrigation and Fertilization Rates for Young Peach Plants In Controlled Environment**

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Accurate irrigation and fertilization management for agricultural crops has become a subject of interest, due largely to widespread problems with drought and fertilizer runoff. Irrigation
and fertilization guidelines are needed for peach growers in the southeastern United States. to avoid plant stresses and improve production. Although studies in controlled environment cannot be easily translated to field situations, they can provide a better understanding of the trees' physiological responses to different irrigation and fertilization conditions. Greenhouse experiments were conducted: one to test different irrigation rates and another to test different fertilization rates, with both experiments testing two scions (‘Flavorich’ and ‘Julyprince’) and two rootstocks (‘MP-29’ and ‘Guardian’). For the irrigation experiment, flower bud break percentage was affected by the scion and rootstock treatments. Plants receiving the highest irrigation level (volumetric water content (VWC) of 45%) were ~35% taller than the treatments with a VWC of 15 and 35%. Plants growing with a VWC of 45% or those grafted onto ‘Guardian’ displayed the greatest trunk cross-sectional area increase (TCSAI). In general, plants receiving the lowest irrigation level (VWC of 15%) had the lowest stem water potential in comparison to those receiving more water. For the fertilizer experiment, ‘Flavorich’ scion reached peak bloom faster and had more abundant bloom than ‘Julyprince’. Photosynthetic activity was affected by the interactions between the fertilizers vs. scion and fertilizer vs. rootstock treatments. Plants receiving greater amounts of fertilizer (18, 13.5, and 9 g of N per plant) had ~2x the TCSAI than the plants receiving the lower amounts of fertilizer (4.5 and 2.3 g of N per plant). Higher doses of irrigation and fertilization tend to increase plant height and TCSAI. However, the photosynthetic activity appeared to be less dependent of the irrigation and fertilization rates, similar to the bud break progression, which was found to be more dependent on the scion and rootstock cultivars.

Validation of a Stable Major-effect Flowering Time Quantitative Trait Locus in Watermelon

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Watermelon (Citrullus lanatus) is a major vegetable crop widely grown in the warmer parts of the world. Commercially cultivated watermelon is predominantly monoecious, with male flowers appearing first. Flowering time is crucial in watermelon production as it determines time of fruit set. Early flowering is desirable because it enables crops to escape biotic and abiotic stresses that are intensified by long production cycles. For seedless watermelon breeding, production is reliant on synchronized flowering of diploid pollenizers and the triploid watermelon cultivars. Incorporation of single nucleotide polymorphisms (SNPs) for marker assisted selection (MAS) of flowering time in watermelon breeding would potentially aid in selection for the early flowering trait, which would shorten the production time. Moreover, seedless watermelon breeding would be enhanced through appropriate triploid-diploid pairings. A major quantitative trait locus (Qdff3-1: 12Mb-17Mbp) responsible for ~50% of the phenotypic variation observed for days to female flower was previously identified on chromosome 3 of watermelon. Potential candidate genes underlying the locus include FT, TEMPRANILLO and a recently identified PIP-kinase (Cla002795). The objective of this study was to validate the Qdff3-1 locus and identify SNPs that are significantly associated with the trait, which may be applicable for MAS of flowering time in watermelon. A combination of QTL-seq and candidate gene sequencing was used to identify SNP markers in the region and Kompetitive Allele Specific PCR (KASP™) assays were developed for high throughput genotyping. Potential markers for selection were tested in a recombinant inbred line mapping population and validated on a cultivar panel. Markers that represent potential tools for fine-mapping the QTL have been identified and may be applicable for MAS of flowering time in watermelon.

Where do Nutrients Go When Peach Trees are Fertilized?

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Peach trees are often fertilized without considering different ripening seasons. Nevertheless, peach trees from distinct ripening seasons might have different nutritional needs and might require different fertilization programs instead of a calendar based, uniform fertilization plan. In this research study, we selected 18 trees of six cultivars of three ripening seasons (early-season: ‘Desiree’ and ‘Spring Snow’; mid-season: ‘Sweet N Up’ and ‘Coralstar’; late-season: ‘Snow Gem’ and ‘SnowKing’), and measured the total amount of nutrients removed by pruning, thinning, harvesting and leaf fall. The results from the first two years showed that early-season peach trees lost more nutrients through pruning and leaf fall than mid- and late-season peach trees. On the other hand, mid- and late-season peach trees lost more nutrients through harvesting compared to early-season peach trees. Annual leaf analyses reflected that all peach trees were in the sufficient nutrient range, and early-season peach trees had significantly higher phosphorus, potassium and calcium concentrations compared to mid- and late-season peach trees. These results suggest that early-season peach trees might need less fertilization in order to maintain a healthy balance between vegetative growth and yield. Results from this research may cast light on how to improve orchard fertilization, especially in the southeastern United States.

Extension Section

Extension Education on Peach Dormancy and Innovative Bud Break Techniques in Low-chill Winter Season

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Moderate to severe chill insufficiency occurred during 2015–16 and 2016–17 dormant seasons in the southeastern United States affecting peach and other temperate tree fruit production and overall plant health in the region. Insufficient chill accumulation causes delayed and sporadic flowering, which leads to reduced returns to the growers and a protracted harvest period. In severe cases chilling insufficiency may lead to lack of leaf development and even tree death. Experimental plots were set up at the Chilton Research and Experiment Center, Clanton, AL, during the 2016–17 dormant season where various plant growth regulator treatments, rates and timings were investigated to determine their effect on peach bud break in low-chill winter season. An extension education program was developed by the Commercial Horticulture Team, Alabama Cooperative Extension System to provide peach producers and industry stakeholders with the most current management information. As a core part of the programmatic effort, Amnon Erez, professor emeritus from the Agriculture Research Organization, Israel, and a distinguished international lecturer was invited to provide information on innovative bud breaking techniques in low-chill winter seasons during the Alabama Fruit and Vegetable Growers Association Conference. Growers’ survey revealed that 62% of respondents plan to change their management practices in the future based on newly acquired knowledge.

Sweetpotato Vine Multiplication Training in West and North Africa

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Sweetpotato growers in rural counties in Liberia rely on their experience within the field to make sweetpotato production practices. Technical assistance and training in sweetpotato vine multiplication and nursery management practices to growers, field personnel and extension agents delivered. The Farmers’ Organization for Food Security, Inc., assists sweetpotato growers in Montserrado county hosted training under the farmer to farmer (F2F) program. The objective of the training was to train farmers in sweetpotato vine multiplication and propagation techniques and to set up a program that offers them a means of rapid multiplication of planting material for their farms. A total of 43 farmers and field assistants participated in this training including male and female. The training was held in the classroom (theoretical) and in the nursery (hands-on) and topics covered on raising healthy vines, multiplication, nursery management, weeds and post-harvest. Participants gained knowledge on micropropagation techniques to raise disease free and quality vines and natural sources of pest-disease control solutions. Sweetpotato growers needed skills and knowledge on the current techniques in sweetpotato production that they can use in developing products of higher quality in Egypt. Twenty-one trainees (male and female) were trained in good agricultural practices, variety selection, mother block, irrigation, fertilization, plant protection, and basics of harvesting and handling.

Functional Motivations of Extension Master Gardeners

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Extension Master Gardener (EMG) Volunteers are individuals recruited, trained, and coordinated by Extension to deliver consumer horticulture programming to noncommercial audiences throughout the United States. Recognizing the sizeable investment in recruiting and training these volunteers, it is essential to find ideal candidates for the program. Best management practices for volunteer motivation and long-term retention include making best matches between the reasons individuals want to volunteer and the opportunities available to serve. Previous research utilizing the widely respected Volunteer Functions Inventory (VFI) indicated that Understanding and Values are primary motivational functions for EMG volunteers. In an online 2016 national survey of EMGs using the VFI to measure motivations for volunteering, Understanding was the top motivating function, while Career remained the least motivating function. While results did not confirm the original 6-factor structure of VFI analysis, they did confirm motivational trends seen in other volunteer studies.

Familiarity and Attributes of Plantable Biodegradable Containers Among Environmental Horticulture Firms

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Plastic containers are the primary container option utilized by the Green Industry for ornamental crop production. Although biodegradable containers of various types also have been available, their adoption has been slow. Previous research has shown that these containers aid in plant growth and limit root disruption during installation. In addition, they reduce plastic waste and can increase labor efficiency. It is crucial to assess level of knowledge and use of biodegradable containers by horticultural producers and installers to help explain their slow rate of adoption by the industry. An online survey instrument was implemented to assess producer and landscaper knowledge and familiarity regarding biodegradable containers in the state of Georgia. Results indicated 83% of horticultural producers do not purchase biodegradable containers. However, peat biodegradable containers were primarily purchased when these containers were used. Horticultural producers and installers agreed that use of plantable containers can limit use of plastic containers. Plant installers also suggested that use of these containers has the potential to acceleration plant installation, reduce worker
time during the installation process, and eliminate cleanup that occurs when using plastic containers during planting. The survey results suggest a need for augmented outreach to producers and landscapers. Future work also should focus on education of the public to increase demand on the consumer end that could translate to wider adoption of biodegradable containers.

Development of a High School Viticulture Course Curriculum

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A high school viticulture course curriculum was developed by the Texas A&M AgriLife Extension Service in response to a request from Texas schools. The curriculum contains six teaching modules with teaching materials for eighteen topics: an introduction to viticulture, careers in viticulture, the history of viticulture, grape species and cultivars, grapevine biology, grapevine propagation, vineyard site selection and evaluation, soil science, soil management and fertility, vineyard establishment, trellis and training systems, vineyard equipment, grapevine training and pruning, integrated pest management, canopy management, harvest, and record keeping. The curriculum consists of teacher notes, assignments, suggested activities, presentations, and supporting material. A web-based version of the course was also created to provide multiple teaching options.

Coping with Rose Rosette Disease in the Great Plains

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Rose rosette disease (RRD) was first reported in the United States in 1940. Since then the disease has become widespread east of the Rocky Mountains particularly with the advent of free-blooming cultivars that landscapers utilize in virtually every project. Even though the causal agent was identified in 2011 and a better understanding now exists of the eriophyid mite that transmits the rose rosette virus, RRD is still pervasive and thus responsible for thousands of dollars in damages to producers, landscapers and ultimately, end consumers. The disease is readily spread through movement of the mite by crawling, wind, or through human-induced physical movement of the mite. Consequently, rose trials were initiated at Oklahoma State University and Kansas State University in 2016. Researchers hope to find commercially available rose species or cultivars that possess RRD resistance. These selections will be presented to breeders for consideration in future rose breeding programs. In addition to cultivar trials, best management practices such as pruning techniques, interplanting non-rose species, eriophyid mite control, etc. are being studied in order to slow progression of this disease. Second year results of rose rosette disease incidence will be reported.

Horticultural Practices and the Potential for Disease in Georgia Blueberries

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It is well known that certain horticultural practices in crop production can exacerbate or help suppress the potential for plant disease. Mechanical hedging has become a common practice in some perennial crops, and in wine grapes in particular, it has been demonstrated that the use of fungicides after the plants are hedged is justified in reducing disease pressure from wound-infesting plant pathogens such as species within the Botryosphaeriaceae complex. In blueberry, which is also commonly hedged, there is currently no data to demonstrate fungicide efficacy against these fungal species after postharvest hedging. In 2016 and 2017, tops of southern highbush blueberry cultivar ‘Star’ were hedged flat. The following fungicides from different FRAC classes were applied the same day after hedging: azoxystrobin (Abound), fludioxonil (Cannonball), penthiopyrad (Fontelis), prothioconazole (Proline 480SC), potassium phosphite (Prophyt), and thiophanate-methyl (Topsin 4.5FL). Plots were five plants long with each of the three middle plants inoculated with a different isolate of Botryosphaeriaceae fungi: Neofusicoccum ribis SEGA18, N. ribis SEGA10a, or Lasiodiplodia theobromae SEGA32. Inoculations were done by stamping a 7-day potato dextrose agar culture of each isolate with an inverted microcentrifuge tube, and then applying the tube inoculum to the cut stem with parafilm 2 h after fungicide application. The experiment included untreated (no fungicide) and uninoculated (no fungal inoculum) controls. Stems were assessed for Botryosphaeria stem blight severity 10 and 20 days after inoculation. Results indicated that thiophanate-methyl, which is currently not labelled in blueberry, significantly reduced lesion length on inoculated stems in both years.

Education Section

Horticulture Student Learning Outcome Assessment at the University of Arkansas: An Update

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An action plan was instituted to implement a previously developed student learning outcome assessment plan for the Horticulture Department located within the Bumpers College of Agricultural and Life Sciences at the University of Arkansas. Areas targeted for assessment are critical thinking skills, written and oral skills, and selected discipline specific skills as defined in the approved
Digital Portfolio: A Way to Engage Students in Hands-on Learning Activities in an Online Course

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Laboratory exercises and hands-on activities are important part of student learning, and are regarded as application of skills. Courses with large enrollment, however, struggle with incorporating such activities. As the number of online courses increase in higher education, how to teach science laboratory activities online has become one of the most significant challenges in online education. Herbs, Spices, and Medicinal Plants is an online undergraduate course taught at The University of Georgia with an average enrollment of 160 students (2015–17). As part of the assessments, students are tasked with completing a digital portfolio, based on a series of hands-on activities. Each student compiles his/her digital portfolio on a peer-shared website; the activities directly apply module concepts, such as plant botany, phytochemistry, extraction of herbal phytochemicals, preparation of herbs, among others. Each activity consists of detailed instructions, some including external content (e.g., short you-tube videos) and multi-level rubric. The portfolio accounts for 25% of the course grade. Course evaluations from the past three years consistently show that majority of the students rate the hands-on activities as a favorite part of the course. Students reflected that the digital portfolio engaged them more intimately with the content and allowed them to explore the concepts in a direct and practical way, e.g., making tea, cooking with herbs, extracting emollients from herbs. Some students commented that the cost of the materials (approx. $50) required for the hands-in activities was a drawback. Based on our experience, we conclude that incorporating simple hands-on activities in an online course is valuable means of assessment and achieves the purpose of application of skills.

High Impact Learning Experiences for Students in the College of Agriculture at Auburn University

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Recently, the College of Agriculture (COAG) at Auburn University (AU) created a new strategic plan that has as one of its instructional objectives to “deliver high impact, innovative instructional programs through engaged student learning”. One tactic to achieve this is to “incorporate inquiry-based, international, and experiential learning opportunities throughout curricula”. Faculty members in departments throughout the COAG have created high impact learning (HIL) opportunities for students including undergraduate research fellowships, course-based undergraduate research experiences, ePortfolios, study abroad, domestic study tours, and multidisciplinary student teams for external competitions. Some majors such as Animal Sciences and Biosystems Engineering require some of these activities for their students, while other departments currently offer them as optional. In addition to these opportunities for student development, the COAG has recently developed departmental as well as interdisciplinary Faculty Learning Communities (FLC). Previous research has shown that faculty working collaboratively in an FLC are more likely to persist in their efforts to incorporate HIL experiences into their courses and curricula. These COAG FLCs have received support from several campus resources to guide them in the development of HIL activities. Campus resources such as the Office of University Writing, the Miller Writing Center (student support), the AU ePortfolio Project, the Biggio Center for Enhancement of Teaching and Learning, and Auburn Online have all provided technical and pedagogical expertise to assist COAG faculty in creating and delivering these HIL experiences. Current efforts with HIL practices have been faculty driven and thus reflect faculty buy-in for these approaches and suggest a high likelihood of continuation and expansion.

Floriculture, Ornamentals, and Turf Section

Container Trial of 150 Azalea (Rhododendron spp.) Cultivars to Assess Insect Tolerance and Bloom Characteristics in a Production Environment

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This study was carried out at The Center for Applied Nursery Research over a two-year window (2015–17) and examined 150 commercially available taxa to determine plant growth and flowering characteristics as well as strawberry rootworm (*Paria fragariae*) and azalea lace bug (*Stephanitis pyrioides*) tolerance. All plants were obtained as rooted liners, pruned to 4-inches in height, and repotted into 3-gallon containers filled with 3/8-inch composted pine bark. Irrigation, fertility, and pesticide treatments were conducted following the protocol established by McCorkle’s Nursery. Plant growth and flowering included ten individual plants per cultivar, organized using completely randomized block design. Data included weekly observations of plant mortality, if plants were blooming, date of first bloom, date of full bloom, and date of last bloom. Strawberry rootworm and azalea lace bug tolerance utilized 10 individuals per cultivar, placed in an insect-screen covered cold frame (completely randomized design). Insects were inserted via 50 infested plants in July 2015 and insect populations were allowed to increase for 24 months, with tolerance data collected in August 2017. Tolerance data was measured by visually rating plant canopy damage on a 1–10 scale. All data were analyzed using ProcGLM in SAS with means separation via Waller-Duncan Analysis. Seven cultivars suffered complete mortality. Means separation results indicated that cultivars Encore Autumn (EA) Moonlight, Bloomin’ Again (BA) Orange Frost, BNA Rojo, BNA Tropical Blush, Southern Charm, Momo No Haru, and Macrantha Pink flowered for a significantly longer period during the spring compared to other trialed cultivars; ranging from 98–140 days. When compared to other trialed cultivars, EA Amethyst, EA Lilac, EA Moonlight, EA Sunburst, Bloom-a-Thon (BAT) Pink Double, BAT Red, Deja Bloom Cherry Pinata, EA Belle, EA Rouge, and Evermore Light had significantly longer fall bloom period; ranging from 168–182 days. ‘Red Slipper’, ‘BNA Lavendar Twist’, ‘Mother’s Day’, ‘Girard’s Hot Shot’, ‘Amy’, and ‘Girard’s Crimson’ showed the greatest tolerance to azalea lace bug. ‘Chizan’, ‘Flame Creeper’, ‘Momo No Haru’, ‘Gumps Pink’, and ‘The Robe’ showed the greatest tolerance to strawberry rootworm.

**Louisiana Consumer Demands and Willingness-to-pay for U.S.-grown Tea**

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The tea plant, *Camellia sinensis*, was introduced to the United States (U.S.) around 1650, and there were several times in the history that tea was planted in different locations across the country to test for commercial production. U.S. tea consumption reached $12 billion in 2016, and is projected to have a 6% to 10% annual increase over the next ten years. Consumers are increasingly interested in where tea is sourced and whether or not it was produced in an environmentally and socially sustainable manner. The “grow-local” movement in recent years also provides an opportunity for U.S. growers and investors to consider this traditional Asian crop as a new specialty crop. This survey was conducted with 135 Master Gardeners with an average age of 63, and focused on purchasing preference and willingness-to-pay for tea products grown or processed domestically. Results indicated that about 92% of survey participants drink tea, and retail stores and super markets (84%) are major places for purchasing tea products, followed by consumptions at restaurants (48%). Tea bags are still the most popular tea products (82%) followed by ready-to-drink bottles tea (36%). About 19% participant has purchased loose tea in the past 6 months, which is encouraging because currently loose tea is the most profitable type of product for U.S. tea growers. Compared with hot tea, especially those prepared from loose leaf, iced tea is still the most popular form in tea consumption, especially during the summer. For this specific age group, the motivations for drinking tea are (by ranking): taste good, health benefits, and relaxation, and the top three factors affecting purchasing decision were (by ranking) quality, availability, and cost. About 27% participant would prefer purchasing tea grown and processed locally or domestically, while 70% said origin does not affect purchasing decision. About 39% participant preferred tea grown with sustainable production practices, and only 22% would like to purchase tea products that are organically grown. Assuming similar quality, about 54% participant would pay the same price for domestically grown tea as they would for imported tea, and only 22% would like to pay for 20% more for domestically grown tea. These results indicated that there are market opportunities to develop tea into a viable crop for U.S. growers and consumers.

**Modeling Carbon Footprint and Variable Costs for Greenhouse Production of 11.4-cm Begonia**

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Analysis of a model production system for global warming potential (GWP) and variable costs of for a 11.4-cm container of wax begonia (*Begonia × semperflorens-cultorum* Hort.) as part of a 12-plant shuttle tray was conducted using life cycle assessment (LCA). The model focused on production in a gutter-connected, Dutch-style greenhouse with natural ventilation in the northeastern United States based on grower interviews and best management practices. The GWP was calculated as 0.140 kg CO2e and the variable costs would total $0.666 for this product. The container and 1/12 of the shuttle tray were the items of most consequence to GWP (57%) and variable costs (43%). Electricity would account for 13% of GWP and only 2% of variable costs in this model. The LCA is a tool to analyze the impact of individual system components on product GWP and variable costs for identifying possible system modifications to increase efficiencies and decrease environmental impact potential.
American Ginseng (*Panax quinquefolius* L.) Establishment in the Ozark Highlands Region of Northwest Arkansas

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American ginseng (*Panax quinquefolius* L.), an herbaceous perennial with reputed therapeutic value is native to Arkansas but nowhere common with existing populations threatened because of illicit harvesting and habitat disruption. Compton Gardens located in Bentonville, AR (36°10′22″35″N, 94°10′40″W) is a not-for-profit public garden with a mission to conserve and display flora native to the Ozark Highlands Region. Attempts to establish a sustainable population of American ginseng on-site have been unsuccessful. Sites with reported American ginseng populations based on herbarium vouchers were identified to investigate edaphic and ecological indicators of established populations and compared with the planting site at Compton Gardens. One site at Mt. Magazine State Park (35°10′27″N, 93°37′08″W), and two sites in Kingston AR (36°03′2′2.5″N, 93°30′53″W) were selected. No populations were found at the Mt. Magazine site because of recent deforestation and land disturbance. Two sites in Kingston were investigated including one site where plants found in situ and a site where a licensed ginseng grower propagates American ginseng in ground beds simulating native environments. Established populations were growing in silt-loam over clay well-drained soils with soil pH below 6.5 and low levels of phosphorus (23 mg·L⁻¹), and calcium (1506 mg·L⁻¹), and sustained moisture. The Compton Gardens site is characterized by thin clay soils overlying cleft limestone with a brittle frangipan with pH 7.0 and abundant calcium (3452 mg·L⁻¹) and phosphorous (65 mg·L⁻¹) receiving periodic but not constant irrigation. It is suggested that the soil at existing site at Compton Gardens is not conducive to American Ginseng establishment without modification and consistent irrigation. The site visit to Mt. Magazine demonstrated the immediate impact of land disturbance on American ginseng populations in situ.

Container Color Effects on Root Zone Temperature and Growth of Arborvitae (*Thuja occidentalis* ‘Green Giant’)

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Three types of containers (black, white, and a RediRoot™ air root pruning container) and two substrates [pine bark (PB) and 3 pine bark:1 peatmoss (PB:PM)] were evaluated for effects on root zone temperature (RZT) and subsequently plant growth of *Thuja occidentalis* ‘Green Giant’. Simultaneous experiments were conducted in McMinnville, TN, and Mobile, AL, over a period of six months. In the McMinnville experiment, growth index (GI) of plants grown in white containers was 5% and 6% larger compared with plants in black containers at 95 and 120 days after planting (DAP), respectively. Plants grown in PB:PM were 4 and 10% larger (GI) than PB grown plants at 95 and 120 DAP, respectively. At termination, no differences in GI were observed between black and white containers when grown in PB; however, plants in white containers were 10% larger than in black containers when grown in PB:PM. No differences in shoot dry weight (SDW) were observed between black and white containers when grown in PB. Yet when grown in PB:PM, plants in white containers had 17% greater SDW than plants in black containers. In the Mobile experiment, plants grown in white containers had 30% greater GI compared with plants in black containers at termination. Plants grown in PB:PM had 20% greater GI compared with plants grown in PB at termination. In both experiments, RZT was over 38° C at least 15% more of the time in black containers compared with white containers (regardless of substrate). This study demonstrates that white containers can significantly reduce RZT, positively influencing plant growth in ‘Green Giant’ arborvitae.

Nitrogen Speciation in Two Constructed Wetlands Treating Nursery Irrigation Runoff

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Constructed wetlands (CWs) are used to treat a variety of wastewaters from agricultural and urban to industrial. Performance of CWs depends upon design parameters, hydraulic loading, and composition of wastewater. The objective of this work was to characterize how nitrogen (N) speciation and fate was influenced by CW design, season, and age. To accomplish this, water from two CWs treating irrigation runoff received from two distinct production watersheds was sampled monthly for three years. Oxidation reduction potential (mV), dissolved oxygen (mg·L⁻¹) and nitrogen (mg·L⁻¹ of nitrate, nitrite, and ammonium) were recorded at five sites within each of two CWs. The majority of nitrogen in both CWs was present as nitrate. Within the first CW, designed with a deep cell flowing into shallow cell, nitrate comprised 86% of total N in effluent. Within the second CW, designed with three sequential deep cells, nitrate comprised only 66% of total N and ammonium comprised 27% of total N in CW2 effluent. Constructed wetland design and nutrient loading rate influenced N speciation within both CWs.


Fruit Crops Section

A High-throughput Snp Genotyping Platform For Marker-assisted Breeding In Strawberry (*Fragaria ×ananassa*)

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Strawberry is one of the most economically important crops in Florida. The University of Florida strawberry breeding program
has recently been adapting DNA marker technologies for new cultivar development through marker-assisted seedling selection. The availability of a high-throughput genotyping platform is vital for the success of marker-assisted seedling selection in the breeding program for new cultivar development through desirable yield patterns, horticultural characteristics, flavor, disease resistance, and other traits for fruit quality. For utilizing DNA tests in strawberry breeding program, several important traits for flavor (peach aroma) and disease resistance Phytophthora/Colletotrichum crown rot and angular leaf spot have been identified. DNA markers were developed for an effective marker-assisted seedling selection. Other important traits such as anthracnose, powdery mildew and charcoal rot resistance have been characterizing to develop new DNA tests. This application, therefore, is to continue the research to perform identifying important traits and developing DNA markers for enhancing fruit quality and disease resistance breeding through marker-assisted selection.

Frost Protection of Low Tunnels to Organically Managed Strawberries in Field and High Tunnels

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Outofseason organic strawberries are profitable by filling a gap in fresh markets throughout North Carolina. However, growing strawberries out-of-season faces many challenges, primarily cold damage. The objective of this study was to determine if low tunnels (LT) would provide additional frost protection in either high tunnel or open field production systems. Conducted on the University Farm in Greensboro, NC, day neutral varieties (Albion and San Andreas) and June-bearing varieties (Camino Real, Benicia, Winterstar and Radiance) were tested under TunnelFlex Retractable Low Tunnels (28” W x 100’ L x 39.5”H) in two high tunnels (30’ W x 96’ L) as well as in open field. In each system, the experiment design was a completely randomized design conducted as a splitplot treatment design for June-bearing varieties, or a split-split plot design for day-neutral strawberries. All strawberry plants experienced cold damages to flowers and fruit in mid-January, February and early March 2017. Inside the June bearing strawberry high tunnel, cold damage to open blooms and fruit was not different with or without LT in January and March. In February, however, more damage occurred to flowers and fruit under LT, which was possibly due to the fact that plants under LT had more flowers and fruits at the time of cold events. Inside the day-neutral strawberry tunnel, LT provided extra frost protection to flowers and fruit in February, not in January and March. For example, more than 60% of flowers were damaged by the cold event in February without LT in the high tunnel. In the field, LT protected day neutral varieties from cold damage to flower (11% damage vs 60% with or without LT) in January, and to fruit damage in February (4.6% with LT versus 14.8% without LT). LT did not provide extra protection to flowers and fruit of June-bearing varieties. Overall, LT provided extra frost protection to day-neutral varieties in high tunnel and open field. This protection, however, was not obvious to June-bearing varieties.

Status of Kiwifruit Research in Texas

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Kiwifruit vines were planted in Jan. 2011 in a full sun location in Nacogdoches, Texas with two female plants per male. Two female golden kiwifruit (Actinidia chinensis) cultivars, ‘AU Golden Dragon’ and ‘AU Golden Sunshine’ were coupled with two males, ‘CK3’ and ‘Tiger’, respectively. One green kiwifruit (A. delicosa) cultivar ‘AU Fitzgerald’ was coupled with the male cultivar, ‘AU Arthur’. The leaf canopy area occupied by a single row of eight ‘AU-Golden Dragon’ vines and five ‘CK3’ vines was 880 ft² (82 m²). First production in September 2014 resulted in 144 lbs (65 kg) of kiwifruit from eight vines of ‘Golden Dragon’, with much less production from the other two female cultivars, ‘AU Golden Sunshine’, and ‘AU Fitzgerald’. In September 2015, 875 lbs (397 kg) of ‘AU Golden Dragon’ kiwifruit were harvested from eight vines. A consumer acceptance evaluation with 63 participants rated the fruit at 8.84 on a scale of 0–10. Crops in 2016 and 2017 were light, attributed perhaps to low chilling, poor flowering of two male plants, and an inappropriate pruning strategy. In 2014–2017, only ‘CK3’ has flowered heavily. A Texas Department of Agriculture Specialty Crop Block Grant was awarded in 2017 to Stephen F. Austin State University (SFAUSU) and Texas A&M University (TAMU) and the research plots at both TAMU and SFAUSU have been expanded and a replicated variety trial is in place, including the addition of a new golden cultivar, ‘AU-Gulf Coast Sunshine’. Future trials are planned with research plots at TAMU, SFAUSU, North Texas Community College at Mount Pleasant, Texas, and additional trials with cooperating farmers. In 2017, kiwifruit plantations and research plantings in China, New Zealand, California and Alabama have been visited and a summary of that reconnaissance effort is presented. Six new varieties from China will be exiting USDA quarantine in Dec. 2018. Several perceived adaptation-related challenges to production have been identified, and will serve as the focus of applied research efforts by Texas A&M. These include: soil alkalinity, insufficient winter chilling, warm-temperature interruption during winter chilling accumulation, reduced cold hardiness due to de-acclimation, and excessive boron in irrigation water.

Comparing the Use of Tissue Culture and Rooted Cutting Plants of ‘Mp-29’ Rootstock As A Starting Material for Peach Budding in the Southeastern United States

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One of the major characteristics of peach production in the southeastern United States is the successive replanting of peaches for multiple generations. This has increased the amount of pathogen and pests, resulting in reduced tree life expectancy. Currently, one of the most devastating diseases for the peach industry is oak root rot (Armillaria tabescens). ‘Guardian’ rootstock, and most peach rootstocks currently available, are highly susceptible to this disease. The MP-29 rootstock released in 2011 has superior resistance/tolerance to most of the pests and diseases present in the southeastern U.S. However, the use of MP-29 in commercial production has been limited due to its vegetative propagation. Traditionally, peach rootstocks are seed propagated with germination, budding, and tree sale occurring in one-year cycle. MP-29 vegetative propagation is characterized by a two-year cycle, which has proven a hurdle in nursery production adoption thereby limiting its usefulness commercially. The objective of this research was to investigate the use of tissue culture plants of MP-29 as a starting material for nursery establishment. Three rootstocks were used: 1) ‘Guardian’ seed propagated plants, 2) one-year old rooted cuttings of MP-29 (RC-MP29, traditionally used in nursery production), and 3) tissue culture MP-29 plantlets (TC-MP29). All rootstocks were grafted to scion varieties ‘Scarletprince’ and ‘Early August Prince’ in Fort Valley, GA. A randomized complete block design with four replicates as blocks per variety and ten plants per replicate were used. Plant survival at the beginning of the test (%), graftable material at start (%), plant survival at the end of the test (%), grafting success (%), caliper (mm) and height (cm) at grafting (rootstock) and at the end of the season (scion) were measured. At the beginning of the test, plant survival ranged from 100% to 91.3%, and graftable material ranged from 100% to 92.7%. At the end of the test, statistical differences were observed for plant survival for ‘Guardian’ (70%) in comparison to TC-MP29 (42.5%) and RC-MP29 (30%). Similarly, ‘Scarletprince’ scion plants had a higher survival in comparison with ‘Early August Prince’, with 62.5% and 32.5%, respectively. ‘Guardian’ rootstock caliper and height at grafting was 8.5 mm and 105.5 cm in comparison to RC-MP29 of 6.5 mm and 75.8 cm, and TC-MP29 of 5.7 mm and 75.3 cm, respectively. Budded trees on ‘Guardian’ rootstock produced scion trees with a caliper of 5.7 mm and a height of 40.1 cm in comparison to RC-MP29 rootstock with scion trees with a caliper of 5.5 mm and 29.7 cm of height and to TC-MP29 rootstock with scion trees with a caliper of 5.4 mm and 32.3 cm of height. ‘Scarletprince’ scions were taller than ‘Early August Prince’. The use of TC-MP29 allowed the production of finished trees for sale and commercialization in one-year cycle, similar to ‘Guardian’ propagated plants. Additional research will be pursued to optimize the nursery propagation protocols.

‘Effie’ is the sixth nectarine released from the University of Arkansas System Division of Agriculture (UA) peach and nectarine (Prunus persica (L.) Batsch) breeding program. Prior nectarine releases include ‘Arrington’, ‘Bradley’, ‘Westbrook’, ‘Bowden’, and ‘Amoore Sweet’. The UA peach and nectarine program was established in the 1960s with the goal of combining novel flesh textures with a range of flesh colors, flavors, and acidity levels in adapted nectarine and peach germplasm to expand options for growers beyond standard-acid, melting, yellow-fleshed peaches. ‘Effie’ is the first mid-acid, white-fleshed nectarine release from the UA breeding program. It is also the latest ripening nectarine release from UA, ripening approximately a week after ‘Amoore Sweet’ and ‘Bowden’ and two weeks after ‘Bradley’. ‘Effie’ has firm, non-melting flesh, high blush, and excellent white nectarine flavor. It also has good resistance to bacterial spot (caused by Xanthomonas arboricola pv. pruni) and should provide a high-quality option for growers in areas where bacterial spot disease is a concern. Overall, ‘Effie’ is an excellent mid-season white nectarine that is well adapted to the mid- to upper-southern United States and other areas of the world with similar climatic conditions.

**Understanding Armillaria Root Rot Tolerance/Resistance in Prunus**

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**Armillaria** root rot (ARR) disease is affecting stone fruit and nut crops throughout the U.S. and is the greatest threat to peach and cherry orchard sustainability in the southeastern U.S. and the Great Lakes Region, respectively. ARR has become a serious and widespread problem in the major tart and sweet cherry production regions of Michigan and is responsible for tens of millions of dollars in losses in historic peach production regions of Georgia and South Carolina. The causal soil-borne fungi, *Armillaria* spp., infects the root system, typically killing trees when they are reaching their maximum productivity, making orchards unprofitable, and the infected land unsuitable for continued stone fruit production. At present, there is no environmentally safe, clean management strategy for ARR in *Prunus* spp. tree fruits, and the few management options that are available are only marginally effective at best. The longer peach and cherry trees are cultivated at a single location, the more fungal inoculum in the form of infested root pieces builds up in the soil. Therefore, replant sites with a history of ARR are considered economically unfeasible for continued peach and cherry cultivation. At such locations, it is not uncommon for trees of only 3 and 4 years of age to succumb to ARR. Therefore, the most economical and potentially effective solution to combat *Armillaria* is through use of genetic resistance. To understand ARR tolerance/resistance in *Prunus* L. and uncover potential sources of tolerance/resistance that could be used in rootstock breeding, we used in vitro...
infection to screen 81 *Prunus* wild accessions from the National Clonal Germplasm Repository in Davis, CA. Preliminary results of the *in vitro* screen and implications for breeding new resistant rootstocks via introgression of resistance genes from wild relatives into stone fruit-compatible rootstocks will be presented.

### Lack of Chill and the Use of Hydrogen Cyanimide Applications in Peach Production in Georgia

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The 2016 and 2017 seasons in the southeastern United States were characterized by unseasonably warm winters. In Fort Valley, Georgia, the chill hour accumulation from 1 Oct. 2015 to 15 Feb. 2016 was 565 chill hours, and from 1 Oct. 2016 to 15 Feb. 2017 was 438 chill hours using the modified Weinberger model. The historical average for this location was 843 chill hours. The lack of chill in peaches for these seasons was characterized by delay or complete lack of bloom. Other characteristics included erratic vegetative bud break, extreme rootstock sucker production, and in major cases limb and scaffold death. The objective of this research was to study the effect of dormancy breaking compounds in yield, bloom and vegetative bud break progression. In 2016, the use of hydrogen cyanamide at 1% and 1.5% concentrations applied at three different dates resulted in non-statistical significant differences for yield for ‘Springprince’, ‘Juno prince’, and ‘Scarletprince’ peach varieties in comparison with the unsprayed control. ‘Springprince’ yield ranged from 17.2–23.9 kg per tree, ‘Juno prince’ yield ranged from 17.2–23.9 kg per tree, and ‘Scarletprince’ ranged from 21.8–4.9 kg per tree. In 2017, the use of a 1.5% hydrogen cyanamide spray in comparison with the unsprayed control resulted in higher proportions of flower buds per developmental stages for ‘Goldprince’ peach variety. ‘Cary Mac’ peach variety did not show any differences between sprayed and unsprayed control for proportions of flower buds per developmental stage. Similarly, vegetative bud progression in ‘Cary Mac’, ‘Redglobe’, ‘Harvester’ and ‘Contender’ peach were evaluated after the use of pruning, hydrogen cyanamide 2%, hydrogen cyanamide 4%, Maxcell, ProGibb® 4%, and potassium nitrate. These varieties suffered extreme cases of lack of vegetative progression due to lack of chill. No differences were observed among treatments. In summary, the results obtained from these experiments were not consistent across varieties and experiments. The identification of an universal tool to address the issues of lack of chill in peach is important and additional trials need to be pursued in the future.

### Assessing Secondary Bud Fruitfulness of Two *Vitis* Cultivars Grown on the Texas High Plains: Second Year Update

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In 2017, there were approximately 1767 grape bearing hectares, and 394 wineries within the state of Texas. Within the state, the grape and wine industry had an overall economic impact of $13.1 billion. The vast majority of producing vineyards in Texas are subject to late spring frost damage which can severely reduce crop yield. If growers within Texas were knowledgeable regarding grape cultivar secondary bud fruitfulness, secondary bud fruitfulness could possibly influence variety selection during vineyard planning and planting. Research regarding fruitfulness of primary/secondary buds within Texas is scarce. Therefore, objectives of this experiment were to complete a two-growing-season study comparing fruitfulness of shoots grown from primary and secondary buds of two *Vitis* cultivars on the Texas
Impact of Rootstock on Growth and Fruit Composition of ‘Blanc Du Bois’ Grapes

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‘Blanc Du Bois’ (\textit{Vitis} spp.) is the most popular Pierce’s Disease tolerant white wine bunch grape cultivar in Texas. It is primarily grown on its own roots and micronutrient deficiencies are commonly observed in calcareous soils. A field study was conducted in the Texas Gulf Coast in a calcareous clay loam (pH 8.2) to evaluate the impact of rootstock on ‘Blanc Du Bois’ vine growth, yield components, and fruit composition. Ten rootstocks were tested: Dog Ridge (DR), Salt Creek (SC), 1103 Paulsen (3P), Kober 5BB (5B), Teleki 5C (5C), UCD GRN-1 (G1), UCD GRN-2 (G2), UCD GRN-3 (G3), UCD GRN-4 (G4), and UCD GRN-5 (G5). G1 consistently produced the smallest vines while SC, 5B, and 3P produced the largest. Pruning weights ranged from 0.17 to 1.07 kg per vine over three years of study. In 2016, yields ranged from 2.38 kg per vine for ungrafted ‘Blanc Du Bois’ to 4.79 kg for 3P. The differences in yield observed across rootstocks were a result of smaller clusters and berries. At harvest, ungrafted ‘Blanc Du Bois’ had the lowest soluble solids and highest acidity. Tissue testing and visual chlorosis ratings suggest the differences in yield components and fruit composition were a result of vine nutrient status.

Seasonal Pattern of Leaf Nutrients in Three Southern Highbush Blueberry Cultivars under Conventional Commercial Production in South Georgia

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Southern highbush blueberries (SHB; \textit{Vaccinium corymbosum} L. interspecific hybrid) are estimated to be planted in 50% of the production area in south Georgia. An important management tool to identify fertilization program efficacy is leaf tissue nutrient analysis. However, information on nutrient levels outside of recommended sample timing and for new cultivars has yet to be reported. The objective of this study was to survey seasonal trends in leaf nutrient levels of SHB ‘Emerald’, ‘Farthing’, and ‘Rebel’ for 6 macro (N, P, K, Mg, Ca, S) and 5 micro (B, Zn, Mn, Fe, Cu) nutrients. Samples were collected from a commercial farm in Lakeland, GA. Fertilizer applications were by granular and liquid applications at a total of 108 kg/ha N: 10–10–10 w/ micros at 27 kg/ha and 10–5–5 at 81 kg/ha, respectively. Postharvest samples for all cultivars (15 May) were within sufficiency levels except Fe (avg. 46 ppm), which was deficient. N and Fe decreased in concentration from April to October (2.3% to 1.6% and 53 ppm to 33 ppm, respectively). Significant variability was observed throughout sample timing and cultivar for Mg, B, Zn, Mn, and Cu. Samples for P (0.09% to 0.13%) and S (0.14% to 0.19%) were similar through the season. Potassium increased significantly in October compared to other sample dates (0.4%...
to 0.5% April to September; October 0.6% to 0.9%). The Ca samples increased until hedging and new growth after hedging showed decreased concentration in leaf tissue then continued to increase as the season progressed. This work showed variation in leaf nutrients through the season and by cultivar; postharvest leaf tissue samples were within sufficiency ranges for SHB grown in Georgia; and hedging significantly affected concentrations on some nutrients. Thus, best practice for efficacy of fertilization program for newly released cultivars should include sampling leaves postharvest before hedging.

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Fruit Quality and Performance of Golden Kiwifruit (Actinidia chinensis) Cultivars in Central Alabama

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The performance of Actinidia chinensis cultivars in central Alabama has been evaluated for many years, with the earliest plantings occurring at the Chilton Research and Extension Center, Clanton, AL in the mid-1990s. The bloom period of A. chinensis female cultivars and male vines were closely monitored for the 2009 and 2010 seasons. Fruit quality attributes were evaluated for three seasons, 2014 – 2016. Ten average sized fruit were randomly selected from vines weekly beginning in early Aug. through mid-Oct. to assess weight, firmness, soluble solids content, flesh color (hue°), and dry matter content. The bloom period occurred earliest for ‘AU Golden Dragon’ (late Mar. – early Apr.), followed closely by ‘Hort16A’. The bloom period for ‘AU Gulf Coast Gold’ (patent-pending) was 1-2 days earlier than ‘AU Golden Sunshine’, with these cultivars blooming 10-19 days after ‘AU Golden Dragon’. The bloom period for the male cultivar Hortikiwi ‘Meteor’ closely overlaps with ‘AU Golden Dragon’ and ‘Hort16A’, while the male ‘AU Golden Tiger’ bloom period overlaps with ‘AU Golden Sunshine’ and ‘AU Gulf Coast Gold’. The harvest date in central AL for each cultivar based on a hue < 103° appears to be: 15–28 Aug. for ‘AU Golden Dragon’, 29 Aug. – 4 Sept. for ‘AU Golden Sunshine’, 21 Sept. – 2 Oct. for ‘AU Gulf Coast Gold’, and 4–9 Oct. for ‘Hort16A’. A greater dry matter content corresponded with increasing harvest date.

Evaluation of Recently Released Strawberry Varieties and Preliminary Results Regarding their Responses to Varying Rates of NO3 Fertilizer in High Tunnel and Field Production Systems in the Mid South

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As new strawberry varieties are adopted by growers in the Southeast, a review of current standards for fertilizing and monitoring plant nutrient status is needed. A preliminary study to evaluate how five recently released strawberry varieties (Fronteras, Flavorfest, Ruby June, Lucia, Scarlet) and one older variety (Camino Real) perform in high-tunnel and field production systems and respond to varying rates of nitrogen fertilizer was conducted in fall of 2016 and spring of 2017 at the Southwest Research and Extension Center in Hope, AR. The trial was arranged in a split-split design with the main split being the two environments (high tunnel vs field) and the second split being the four rates of fertilizer (High, Standard, Standard + Silicon, Low). The High rate was equal to 1.68 kg N ha−1 per day, Standard 1.28 kg N ha−1 per day, Standard + Silicon was the same but with the addition of 5.08 kg ha−1 of Si applied via Potassium Silicate evenly throughout the season, and the Low rate was 0.70 kg N ha−1 per day. The fertilizer rates were applied in weekly drip applications over 6 weeks in fall (potassium nitrate) and 8 weeks in spring (potassium nitrate until fruiting, and then calcium nitrate) in the field and 2.5 weeks longer in both the fall and spring in the tunnel. The six strawberry varieties were un-replicated within each fertility treatment. Response variables included marketable fruit weights, petiole NO3-N mg/kg content, and two-spotted spider mite (Tetranychus urticae) populations. Variety was the biggest determinant (P = 0.001) of marketable yields in the single year of our trial. Fronteras was the highest yielding variety (P = 0.05) with an average yield of 526.8 g per plant. Flavorfest was the lowest yielding variety (P = 0.05). Fertilizer rate did not impact yields significantly (P = 0.3881). Varieties varied in their base levels of NO3-N (P = 0.001) and there was a significant environment × variety interaction (P = 0.0195) where the plants in the field had higher petiole NO3-N levels than the tunnel and the in the tunnel the standard and standard +silicon rates had higher rates than the high and low rate. This may be due to a more advanced crop stage on average of the plants in the tunnel at the times of sampling. T. urticae populations were higher in the low fertility treatment than in the standard treatment (P < 0.05), which is in stark contrast to previous research but may be due to plant stress.

Evaluation of Ten Strawberry Cultivars for their Production Potential in Central Alabama

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In Alabama, there is increased consumer demand for fresh strawberries and a corresponding growth in interest among farm operators to produce strawberries. In order to meet the demand, there must be technological advancements such as cultivars well adapted to the climate of Alabama. Currently, few science-based trials document the adaptability of strawberry cultivars to the climate of Alabama. The objective of this study was to improve strawberry production by introducing new, better-adapted strawberry cultivars. On 17 Oct., ten strawberry cultivars were...
planted at the Chilton Research and Extension Center (CREC) in Clanton, AL in an annual plasticulture system. The study followed a randomized complete-block design and cultivars (treatments) were replicated four times. Data collected were total marketable yield, total yield, individual berry weight, and cull weight. Cultivars selected for this study were ‘Albion’, ‘Camino Real’, ‘Chandler’, ‘San Andreas’, and ‘Sweet Ann’ (UC Davis); ‘Festival’ and ‘Sweet Charlie’ (University of Florida); ‘Flavorfest’ (USDA-ARS, Beltsville, MD); and ‘Ruby June’ (Santa Cruz). The cultivars ‘Camino Real’, ‘Albion’ and ‘Sweet Ann’ were similar to the market standard ‘Camarosa’ in total marketable yield. In total yield, ‘Camino Real’, ‘Albion’ and ‘Chandler’ were similar to ‘Camarosa’. Cull weight was the highest in ‘Chandler’ but was similar to ‘Camarosa’, ‘Festival’, ‘Sweet Charlie’, and ‘Ruby June’. Cull weight was lowest in ‘San Andreas’ which was similar to ‘Albion’, ‘Sweet Ann’, ‘Camino Real’, ‘Flavorfest’ and ‘Ruby June’. Berry size of ‘Sweet Ann’, ‘Albion’, ‘Camino Real’ and ‘Ruby June’ were 168%, 117%, 116%, and 103% of the berry weight of ‘Camarosa’, respectively. The varieties ‘Camino Real’ and ‘Albion’ performed as well as the market standard ‘Camarosa’ overall. Yield of these varieties were comparable to ‘Camarosa’. They produced large berries and had among the lowest cull weights. Annual strawberry trials should continue to determine adaptability of cultivars.

Evaluating Novel Hybrid Pierce’s Disease Tolerant Winegrape Varieties on Three Training Systems
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Pierce’s disease is a major limitation in growing winegrapes in the southern United States. Currently, the winegrape industry in Georgia is growing and demand for disease tolerant hybrid winegrape varieties has increased. The varieties ‘Blanc Du Bois’, ‘Lenoir’, ‘Norton’, and ‘Villard Blanc’ have been successfully grown in the southern United States with excellent disease tolerance. The success of these varieties is well established for vineyard productivity and wine quality; however, there is currently no information available for Georgia. The objective of this study was to evaluate these varieties for yield and fruit quality on three training systems: Geneva double curtain (GDC), vertical shoot position (VSP), and Watson during the 2015 and 2016 seasons. Varieties were planted in 2013 at Trillium Vineyards (Bremen, GA) in a randomized complete-block design, with three replicates and four vines per replicate. Traits measured were: yield (total cluster number/vine, total cluster weight, 50 berry weight), general fruit quality [%Brix, percent total titratable acids (%TTA)], sugar profile (fructose, glucose, and total sugars), and acid profile (citric, tartaric, ascorbic, succinic, and malic acid). For yield traits, variety overall, training system overall, and variety*training system impacted nearly all traits in both years (P < 0.05). The largest differences were observed for ‘Blanc du Bois’ and ‘Lenoir’, where GDC was approximately double the total cluster number in Watson and VSP in 2016. No differences were observed for all yield traits between the three training systems for ‘Norton’ and ‘Villard Blanc’ in 2016. This suggests training system affects yield traits on some varieties, but does not affect all varieties equally. For general fruit quality traits, results were variable across years and suggest that differences observed for %TTA and %Brix are due to variety differences, and that training system selection influences %Brix. For sugar profiles, only training system overall impacted glucose and total sugars in 2015, and only comparisons of varieties overall had differences in 2016. For acid profiles, no differences were observed between varieties, training system, or variety*training system in both years for nearly all acids for both years. This suggests that differences for sugars are attributed to variety differences, while acid content remains constant between and within these varieties regardless of training system selected. Results from this study will provide vital information to the growing Georgia winegrape industry for training and establishing vineyards for continued growth and success.

Low Tunnels Affect Fruit Quality of Organically Managed Strawberries in Field and High Tunnels
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Locally produced out-of-season, organic strawberries demand high price in North Carolina direct markets. However, low temperatures in winter could negatively affect fruit quality. Although strawberries fruit quality in high tunnel (HT) and open field have been studied, research on the effect of low tunnels (LT) on fruit quality have not been limited. The objective of this study was to analyze if LT would improve fruit quality either in open field or HT. Two day-neutral (DN) cultivars Albion and San Andreas and four June-bearing (JB) cultivars Radiance, Benicia, Winterstar and Camino Real were planted in raised beds with LT or without LT in HT or open field production systems. Five fruit per plot (a total of 15/cultivar/treatment) were collected from HT cultivars in February and April 2017 for lab analysis of color, texture, and titratable acidity. Six to 12 fruit per plot were sampled biweekly from February to May 2017 to measure %Brix, fruit size and weight. In the HT system, color, titratable acidity and %Brix were not affected by LT treatments. In May, DN cultivars under LT had larger fruit (fruit weight of 20.79 g and fruit length of 4.1 cm), compared to those without LT (fruit weight, 15.9 g and fruit length, 3.7 cm). The JB cultivars, however, had smaller fruit under LT than without LT. In April, fruits
were firmer without LT, 8.37 N with LT versus 9.92 N without LT for DN cultivars, and 7.93N versus 9.84 N with or without LT for JB cultivars. In the field system, fruit size and weight were not significantly affected by LT treatment. DN cultivars had significantly higher °Brix under LT (8.43 with LT versus 7.55 without LT) in April, but this was reversed in May (8.85 versus 9.43). For JB cultivars, °Brix was not affected by LT. Based on this one-year research, we propose that LT may benefit DN cultivars although this benefit may not be evident for JB strawberries. Further research is needed to confirm this statement.

Using an Online Survey to Characterize Consumer Opinions of Fresh-market Blackberries

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Blackberry plants (Rubus subgenus Rubus) produce nutraceutical-rich, fresh-market fruit for commercial markets with sales driven by consumer demand for locally grown, healthy foods. Although year-round availability of fresh-market blackberries is increasing, there is limited data on consumer expectations. An online survey was developed by the University of Arkansas Food Science Department, Fayetteville to determine consumer perceptions and purchase intent of fresh-market blackberries. The survey included questions about demographics, liking, purchase and consumption habits, and preferences of images of individual blackberries and blackberries in clamshells. The survey was sent to a database of 5000 consumers, and respondents who completed the survey were offered a chance of incentive. The survey was open from February to May 2017, and 879 consumers completed the survey. The survey respondents were 76.7% female and 23.3% male from ages 21–40 (47.2%), 41-60 (36.0%), and 61 and over (16.8%) with varying levels of education and incomes. Consumers (41.6 %) responded that they consume fresh blackberries once per month, followed by 29.1% once per year, and 12.2% once per week. Consumers that purchased blackberries once per month purchased mostly at grocery stores (33.6%), and once per year 30% purchased at either grocery stores, farmer stores, or roadside stands. About 90% of the consumers agreed with the statements “Blackberry consumption is beneficial for my health” and “I love the flavor of blackberries”. The freshness of the berries (98.1%) and the price (87.8%) were rated highest as reasons to buy fresh blackberries. When shown several individual berries for shape and size, the consumers ranked large, oblong berries higher. When shown two clamshell containers of blackberries, one filled with large berries and one with small berries, 68.6% of the consumers preferred the clamshell with the larger berries. When shown three clamshell containers of blackberries with increasing levels of red drupelets (black drupelets appear red), 72.9% of the consumers preferred blackberries with the least red drupelets as compared to 20.1% that preferred the mid-level, and 7.0% that preferred the most.

The survey showed that participants consume blackberries once per month, like large, oblong blackberries, prefer blackberries with less red drupelets, purchase blackberries based on freshness and price, purchase blackberries at grocery stores, and think blackberries are healthy and have a well-liked flavor. The online survey provided unique data to characterize consumer perception and purchasing of fresh-market blackberries.

Postharvest and Biotechnology Section

Genetic Relatedness among Squash Accessions Varying in Oil, Protein and Fatty Acid Composition

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Seeds of Cucurbita pepo L. (pumpkin) are nutritious and provide an important source of nutrition and income globally. In the United States, pumpkin seed products are sold in retail stores as vegetable oil/ capsules, trail mixes with various nuts, seeds and dried fruit as well as an ingredient in baked products and soups. In the current study, 35 C. pepo accessions were analyzed for their nutrition profile and genetic diversity. Seed oil percentage ranged from 29.33% to 48.41% and was significantly (P < 0.05) negatively correlated with seed protein percentage, which ranged from 19.48% to 31.35%. Linoleic acid (x̅ = 51.19%) was the major fatty acid in the seed, followed by oleic (x̅ = 30.77%), palmitic (x̅ = 9.84%), and stearic (x̅ = 5.63%) acid. Significant negative correlations were found between linoleic and oleic acid (–0.96), linoleic and stearic acid (–0.37), and seed size and seed protein percentage (–0.39). Conversely, significant positive correlations were found between seed size and oil content (0.56 –0.70), seed size and palmitic acid (0.49–0.65), seed size and stearic acid (0.38–0.46), palmitic acid and seed oil percentage (0.50), and stearic acid and seed oil percentage (0.31). Genetic diversity using 39 SSR markers revealed three clusters. Cluster I consisted primarily of hulled seeded accessions grown for edible flesh that had low oil- high protein seeds. On the other hand, cluster II and III consisted entirely of accessions with reduced hulls that had high oil-low protein seeds. Major allele frequency ranged from 0.31 to 0.9, while allele number per SSR marker ranged from 2–9. The mean polymorphic information content (PIC) was 0.44, with five SSR markers having a PIC ≥ 0.65. These markers will be useful for future DNA fingerprinting studies. Collectively, this data suggests wide variation in seed nutrition within C. pepo and provides insight into the genetic diversity within a set of 35 accessions. Several accessions high in oil, protein and unsaturated fatty acids were identified, and will be useful in breeding for enhanced pumpkin seed nutrition.
Quality and Composition of Night-harvested Blackberries

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Blackberry production frequently peaks above 35 °C during the hottest period of the year in the southeastern U.S. and limits harvest to a noon cut off to avoid a short shelf life from heat build up. Additionally, heat exhaustion is not unusual in the field, and further curtails the harvest interval. In this experiment, ‘Ouachita’ blackberries were harvested by hand every 3 hours by an experienced field crew from noon to 9 am in a commercial blackberry field in North Carolina. Miner lamps were used as the light source. Harvested fruit were immediately cooled on farm and transported 1 hour by refrigerated truck for postharvest storage and composition. Highest field temperatures were found between noon and 6 pm (31 °C) and firmest berries were those picked at 3 pm. After 1 day at room temperature, berries from the midnight harvest were firmest and overall appearance of berries harvested at 9 am was best. Blackberries held for 8 days at 4 °C had decay and leak over 20%. Decay, leak, white and red drupelet did not differ significantly among harvest times at days 1 or 8. Soluble solids content decreased slightly at days 1 and 8 to 7.5% and % titratable acid decreased from 1.3 to 1.1 by day 8. Organic acids identified using high performance liquid chromatography were malic, isocitric, citric, ascorbic, oxalic, and isocitric lactone. Total acid content was highest in day 0 berries at 6 pm and lowest at midnight while total sugars (fructose and glucose) were lowest in blackberries harvested at 3 am or 6 pm. Results from this test were mixed for quality and composition.

Butternut Squash in the South: Postharvest Quality After Curing

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Butternut (Cucurbita moschata) offers a value added crop to North Carolina that can be grown across much of the state. In colder climates, where harvest is often done when night temperatures can dip near 0 °C, curing is done to make the rind tougher to prevent decay. In the south, where temperatures are usually warmer at harvest, the need for curing is unknown. ‘Butterscotch’ and ‘Betternut 900’ were harvested from locations in USDA climate zones of 6b, 7a, and 7b. Squash were not cured or cured for 7 days at 21 °C and 75% RH and stored at 14 or 16 °C for 0, 5, or 9 weeks. The influence of storage week and location were greater than that of curing. Within locations, weight loss for cured squash was 0.2 and 1% more for zones 7a and 6b, respectively. Curing increased carotenoid content by 50% compared to no curing and 300% between 0 and 9 weeks storage. Soluble solids content was highest initially in squash from zone 7b and lowest for zone 6b, but was similar across zones by week 9. Curing of squash may be minimal or not needed in areas where night temperatures at harvest are above 20 °C.

Genetic Diversity among Accessions of Cucurbita pepo Resistant to Phytophthora Crown Rot

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Phytophthora capsici Leonian, the causal agent of crown, root and fruit rot in commercial squash production, is an economically important pathogen worldwide. Currently, there are no cultivars resistant to the pathogen commercially available. The goal of the current study was to access the genetic diversity among sixteen C. pepo accessions previously identified as resistant to Phytophthora crown rot using 39 SSR markers and determine their suitability for crosses with elite cultivars. The markers revealed 114 alleles averaging 3.93 alleles per loci and generated average PIC and expected heterozygosity of 0.42 and 0.46, respectively. CMTp235 had the highest PIC and expected heterozygosity of 0.79 and 0.81, respectively, while CMTp202 produced the most alleles (8). The weighted neighbor joining dendrogram and the principle coordinate analysis grouped the genotypes into three major clusters; all susceptible cultivars in one cluster and resistant genotypes distributed across all three clusters. Mean genetic distance within the resistant genotypes was 0.35 and was highest between PI 181761 and PI 615132 (0.61). Of the susceptible cultivars, Black Beauty, a zucchini squash (C. pepo ssp. pepo), was more genetically similar to the resistant accessions than Table Queen and Early Golden (C. pepo ssp. oviifera). Three most resistant genotypes, PI 174185, PI 181761 and PI 615142, were genetically closest to the susceptible cultivars, and form ideal sources for Phytophthora crown rot resistance.

Genetic Diversity and Genome-wide Association Study in Spinach

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Spinach (Spinacia oleracea L., 2n=2x=12) is an economically important vegetable crop worldwide. The objective of this project is to access the genetic diversity and conduct genome-wide association study in spinach. Analysis of genetic diversity was conducted on 462 spinach genotypes, including 365 USDA-GRIN germplasm accessions, originally collected from 33 countries, using SNPs postulated from GBS. STRUCTURE 2.3.4 and MEGA 6 were used for population structure and genetic diversity analysis. The genetic diversity analysis
indicated that there was a geographic (country) factor during spinach cultivar development and spinach production. The spinach accessions from China, India, Iran, Japan, and Nepal grouped together; most European accessions belonged to the same group, but the accessions from Turkey had two unique groups. Most of U.S. spinach genotypes belonged to one larger group and the spinach lines developed from the program at the University of Arkansas were very closer to each other and located within the U.S. group but distinct from others in the larger group from the United States. Association analysis was conducted for disease resistance to Verticillium wilt (Verticillium dahliae) and Stemphylium leaf spot (Stemphylium botryosum f. sp. spinaciae); for pest tolerance to leafminer (Liriomyza spp.); and for mineral elements: boron (B), calcium (Ca), cobalt (Co), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), phosphorus (P), sulfur (S), and zinc (Zn). The general linear mode (GLM) and mixed linear mode (MLM) from TASSEL, compressed mixed linear model (cMLM) from GAPIT, and fixed and random model Circulating Probability Unification (FarmCPU) were used for association analysis. So far, SNP markers have been identified to be associated with resistance to Verticillium wilt and Stemphylium leaf spot; and tolerance to leafminer; and also with oxalate concentration and 14 mineral element concentrations. The SNP markers identified from this study provide breeders with a tool to select associated traits in spinach breeding programs through marker-assisted selection.

A SNP-based Association Analysis for Plant Growth Habit in Worldwide Cowpea [Vigna unguiculata (L.) Walp] Germplasm

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Cowpea is a legume widely grown in Africa, North, Central and South America, and Asia. The cowpea plant growth habits consist of erect, semi-prostrate, and prostrate types. Developing a cultivar while considering plant growth habit is essential within a breeding program since the need for a particular growth habit is region-specific, and significantly depends on the end user preference. Some cowpea growers might prefer erect types over semi-prostrate and prostrate types, while others might choose prostrate types, which provide more leaves for feed supplies to livestock. However, very little is known regarding the genetics of plant growth habit in cowpea to assist plant breeders in developing suitable cowpea cultivars having the desired growth habit plus the other required features. Therefore, the objectives of this study were to conduct an association mapping for cowpea growth habit, and to identify SNP markers associated with this trait. A total of 487 cowpea genotypes were evaluated for growth habit and a total of 1031 SNPs postulated from genotyping-by-sequencing to conduct association analysis for cowpea growth habit. Our results showed that: 1) significant differences in cowpea growth habit were identified between countries, 2) the cowpea erect-type was prevalent, and 3) ten SNP markers, C35060651_729, C35061339_799, C35062457_1855, C35072764_1384, C35080248_2355, Scaffold2771_4351, Scaffold29522_3213, Scaffold35913_2678, Scaffold53560_188, and Scaffold58098_4297, were significantly associated with cowpea growth habit. These results could be used for enhancing marker-assisted selection (MAS) in breeding programs aimed at developing cowpea cultivars having a particular growth habit.

Study on Photoperiodism in Spinach (Spinacia oleracea L.)

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Spinach (Spinacia oleracea L.) are long-day and edible flowering plants in the family Amaranthaceae, native to central and western Asia. Bolting early is a serious problem for spinach production due early flowering causing a reduction in biomass and yield. The objectives of this study were to evaluate spinach photo-period response to day length and to select slow-bolting cultivars. Four spinach varieties, ‘Samish’ from Alf Christianson Seed, ‘F415’ from University of Arkansas, ‘Green Leaves’ and ‘Large Leaves’ introduced from China were used in this study. Plants were grown in greenhouse on top diameter 28 cm × 24 cm height plastic pot containing 1.5 kg Sungro Professional Growing Mix medium. Each spinach cultivar was treated with sunlight of 9 h (dark for 15 h), 12 h (dark for 12 h), 15 h (dark for 9 h) and control (14 h sunlight = 10 h dark), respectively. Bolting days were recorded and biomass for each cultivar under each treatment was measured in 89 day after planted. The two commercial cultivars (Large Leaves and Green Leaves) can flower under nature condition as control and bolting early under either sunlight for 12 or 15 h. In contrast, ‘Samish’ and ‘F415’ did not flower at 9, 12, 15 h and control, indicating they may have slow-bolting ability. ‘F415’ had the highest averaged biomass with 7.2 g/plant; Samish was the second with 7.0 g/plant; ‘F415’ did not flower at 9, 12, 15 h and control, indicating they may have slow-bolting ability. ‘F415’ had the highest averaged biomass with 7.2 g/plant; Samish was the second with 7.0 g/plant; ‘Large Leaves’ and ‘Green Leaves’ were lowest with 6.7 g/plant and 6.8 g/plant, respectively. The research provides information to select and use slow-bolting spinach cultivars in production.

Vegetable Section

Evaluation of Production Practices for Tolerance to Cucurbit Leaf Crumple Virus In Yellow Squash and Zucchini

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The Cucurbit leaf crumple virus (CuLCrV) has been observed in the United States for more than 20 years, though recently has become a significant obstacle for fall production of Cucurbit spp. in southern Georgia. Vectored by sweet potato whitefly (Bemisia tabaci) biotype B, this virus can cause significant losses in yellow and zucchini squash (Cucurbita pepo). Resistance or tolerance to CuLCrV in commercially-available varieties is limited and growers have attempted a range of practices to ameliorate the effects of CuLCrV in fall-grown squash. In Fall 2017, a study was initiated to evaluate several of these practices in tandem to determine the impact on growth and productivity of yellow and zucchini squash infected with CuLCrV. The yellow squash ‘Lioness’ and zucchini squash ‘Payload’ were used. Treatments included standard (11.2 kg·ha⁻¹) and high (33.6 kg·ha⁻¹) applications of nitrogen (N) fertilizer, applications of gibberellic acid (ProGibb LV), and applications of the systemic acquired resistance (SAR) activators, Actigard and Lifegard. Fertility and gibberellic acid applications significantly impacted virus severity and plant vigor in yellow squash and zucchini. Specifically, the high fertilizer treatment combined with no gibberellic acid had lower vigor in yellow squash and zucchini and higher virus severity in yellow squash than the other combinations of fertilizer and gibberellic acid. Yields of both yellow squash and zucchini were also impacted by a significant fertilizer by gibberellic acid interaction. Plants receiving the standard rate of fertilizer with no gibberellic acid had significantly higher yields than the other treatments combined, although yields in all treatments were below what would be commercially acceptable. Cull rates were not affected by any treatment, but were significantly higher in yellow squash than zucchini, with cull rates of 61% and 75%, respectively. Results suggest that while some treatments may give plants the appearance of more vigor, that overall yields of squash infected with CuLCrV are not positively impacted by the practices evaluated.

Chitosan-based Biostimulant Effects on Sweet Onion Crop
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Chitosan, a polymer derived from shellfish, is reported to have antimicrobial properties and to stimulate plant health. We evaluated the effects of the number of chitosan applications of chitosan on sweet onion bulb yield and quality. The study was conducted on sandy loam soil at the Horticulture Farm, UGA, Tifton, GA, and at the Vidalia Onion and Vegetable Research Center (VOVRC), UGA, Reidsville, GA, during the winter seasons of 2015-2016 and 2016-2017. Onion (‘Century’) seedlings transplanted to beds (1.8-m centers) in the second week of December. In Tifton, beds were covered with black plastic mulch and two lines of drip tape per bed. In VOVRC, beds were bare and irrigated with sprinklers. The experimental design was a randomized complete block with six replications and six treatments. Treatments were: 1) Untreated (water); 2) Chitosan applied before planting and 1 month after planting (MAP); 3) Chitosan applied before planting and 1 MAP; 4) Chitosan applied before planting and 1, 2 MAP; 5) Chitosan applied before planting and 1, 2, and 3 MAP; and 6) Chitosan applied before planting and 1, 2, 3, and 4 MAP. Bulbs (20 marketable bulbs per experimental unit) were stored at the Vidalia Onion Postharvest Laboratory, UGA Tifton Campus, for 3 months [2.0 °C, 80% RH, 0.586 kPa of vapor pressure deficit (VPD), 4% CO₂, and 10% O₂]. Means across locations and seasons showed that the marketable total number and weight of bulbs and individual bulb weight of sweet onion were unaffected by the number of chitosan applications. Bulb sour skin (Pseudomonas cepacia) incidence before storage was not impacted by chitosan applications. The onion bulb dry matter and soluble solids concentration before and after storage were inconsistently affected by the number of chitosan applications. Before and after storage, bulb pungency and total phenols concentration were not influenced by the number of chitosan applications. Thus, chitosan applied up to five times during the season had no significant effect on bulb yields or quality.

Overwinter Production of Transplanted Kale and Pak Choi in High Tunnels in Hardiness Zone 7 of North Carolina
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Kale and Pak Choi are popular cool-season crops in high tunnels targeting late-fall and early spring seasons. While kale is continuously harvested for young leaves, pak choi is often harvested once when plants reach maturity. Research on winter production of both crops in high tunnels has been limited. The objective of this study was to test if kale and pak choi could be successfully produced over winter in high tunnels, as our research on microclimates was in support of it. Kale cultivars Nash’s Green, Red Russian and Toscano, pak choi cultivars Mei Qing, Shiro and Win Win were sown in a greenhouse on 11 Oct. 2016 and transplanted on 3 Nov. 2016 in one organic and one conventional high tunnel (30’ W x 96’ L) located on the North Carolina A&T University Farm in Greensboro, NC. Each cultivar was planted into two 14’ long and 1.5’ wide blocks. Each block had three rows of a cultivar in raised bed, with in-row spacing at 12” and between-row spacing at 6”. Row covers (1.5 oz/yard²) were applied over the beds when night temperatures were projected to be below freezing in high tunnels. Both crops grew well in winter. The lowest temperature was −4.9°C inside the high tunnel when the temperature outside was −17.6 °C. For kales, first harvest started 25 days after transplanting. There were no significant differences among cultivars on the marketable yield. Each plant produced about 3.1 to 3.86-stem (leaf) bundles. ‘Red Russian’ had significantly more cull leaves towards the season end. ‘Toscano’ was the
only cultivar bolted, which started from 27 Feb. 2017. Plants in the organic high tunnel had higher yield (27.6 leaves/plant) than those in the conventional tunnel (17.7). For pak choi, ‘Win Win’ had significantly lower No. of marketable plants per plot (27.8) than ‘Mei Qing’ (39.8) or ‘Shiro’ (37.8), although the marketable yield was not different among cultivars. ‘Win Win’ was also the only cultivar with rotten plants resulted from the freezing and thawing process. ‘Shiro’ started to bolt towards the end of the season. Pak choi plants yielded more in the conventional high tunnel (13.4 kg/plot) than in the organic high tunnel (10.3). Our results supported the idea of winter production of both species, and suggest that future research should focus on cultivar evaluations for both crops and succession planting for pak choi.

**Overwinter Production of Direct Seeded Salad and Green Mixes in High Tunnels in Hardiness Zone 7 of North Carolina**

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High tunnels are proven low-tech but efficient season extension tools to improve on-farm productivity and profitability. While most out-of-season production in high tunnels targets fall or spring seasons, our research in plant hardiness zones 7 and 8 has indicated that the microclimates in high tunnels should make winter production of cold-tolerant vegetables possible. The objective of this study was to test if direct-seeded mustard green and lettuce mixes could be successfully produced in winter in high tunnels. Greens mix ‘Ovation’, ‘Elegance’ and ‘Premium’ and Lettuce mix ‘Five Star’, ‘Allstar’ and ‘Encore’ were sowed in raised beds in one organic and one conventional high tunnel (30’ W × 96’ L) located on the North Carolina A&T University farm in Greensboro, NC. Each mix was sowed in two 14’ long and 1.5’ wide blocks in each high tunnel on 13 Oct. 2016. Row covers (1.5 oz/yard²) were applied over the beds when night temperatures were projected to be below freezing in high tunnels. Both species grew well in winter. The lowest temperature was –4.9 °C inside the high tunnel when the temperature outside was –17.6 °C. For the green mixes, the first harvest took place 29 days after sowing, which was seven days later than the number of days on label. The last harvest was done on 9 Feb. 2017. ‘Ovation’ had significantly higher marketable yield (0.69 kg/linear foot bed) than ‘Elegance’ (0.44) or ‘Premium’ (0.50). The green mixes favored organic management as there were five harvests in the organic high tunnel and four harvests in the conventional tunnel. Plants kept producing after the last harvest but the produce quality dropped dramatically, possibly due to low soil fertility as we did not fertigate. For the lettuce mixes, the 1st harvest was done 33 days after sowing, five days later than the labeled days to maturity. Four harvests were conducted in both tunnels. There were no significant differences between cultivars on the marketable yield, which was 0.43 kg/linear foot for ‘Five Star’, 0.55 for ‘Encore’, and 0.57 for ‘Allstar’. The organic managed high tunnel had higher yield (0.61) than the conventional tunnel (0.43). Our results indicated that green mix and lettuce mix would grow well in winter, but fertigation or side-dressing should occur for continuous harvests through winter.

**Impact of Different Wavelengths of Blue Light From LEDs on Biomass and Water Soluble Carbohydrates In ‘Red Sails’ Lettuce (Lactuca sativa) Microgreens**

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Ongoing research continues to establish benefits to plant quality under narrow-band light-emitting diodes (LEDs). What remains unclear are the specific impacts different light quality regimes can have on specialty crop quality parameters. The objective of this study was to compare impacts of different wavelengths of LEDs on biomass parameters and nonstructural water soluble carbohydrates in ‘Red Sails’ lettuce (Lactuca sativa) microgreens. Lettuce were seeded into shallow (25.4 cm × 50.8 cm) flats at 10 g per flat placed into controlled environment chambers (Model E15; Conviron, Pembina, ND). Experimental sole source LED light treatments were applied as: 1) white (Orbital Technologies, Madison, WI); 2) 400 nm + 625 nm + 660 nm; 3) 420 nm + 625 nm + 660 nm; 4) 450 nm + 625 nm + 660 nm; and 5) 470 nm + 625 nm + 660 nm (Ray22; Fluence Bioengineering, Austin, TX). Microgreens were grown at an air temperature of 22 °C with a 14-h photoperiod and a light intensity of 250 μmolm⁻²s⁻¹. All blue/red light treatments had a ratio of 40% blue/60% red light. Three flats per light treatment were utilized, and the experiment was repeated two times. All microgreens were harvested 16 d after seeding and measured for fresh and dry biomass. Carbohydrate concentrations were measured in freeze-dried tissues following hot water extraction using HPLC-ELSD. Lettuce microgreen shoot fresh mass (FM; P ≤ 0.001) and dry mass (DM; P ≤ 0.001) were influenced by light treatment. The highest mean FM of 290.0 g per flat occurred under the white LED treatment, while the lowest FM of 174.5 g per flat was under the 450 nm + 625 nm + 660 nm LED treatment. The highest mean DM of 19.6 g per flat occurred under the 400 nm + 625 nm + 660 nm LED treatment, while the lowest DM of 10.9 g per flat was under the 450 nm + 625 nm + 660 nm LED treatment. Lettuce fructose (P ≤ 0.001) and sucrose (P ≤ 0.001) were influenced by light treatment. Fructose and sucrose concentrations were highest under the white LED treatment, and lowest under the 400 nm + 625 nm + 660 nm LED treatment. The white LED treatment produced the greatest lettuce biomass accumulation, as well as the highest concentrations of water-soluble carbohydrates. Results continue to demonstrate the impacts of light spectra on biomass and quality in specialty leafy crops. Careful management of the light environment for specialty crop production will be needed to maximize yield and quality.
Incidence of Blossom-end Rot and Calcium Accumulation During Fruit Development In Bell Pepper Varieties

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Blossom-end rot (BER) is a physiological disorder that occurs during early fruit growth and results in brown sunken spots at the distal-end of the fruit by maturity resulting in huge economic losses. BER is thought to be a calcium deficiency disorder, where insufficient calcium during fruit growth can lead to cell and membrane disintegration. In order to survey for BER and other fruit parameters we conducted a variety trial consisting of seventeen bell pepper varieties under field conditions at Tifton, GA. Varieties such as SWBP001 Aristotle and 2815 had the highest number of large fruits, and SWBP001, Aristotle and Boca had greater total yield. On the other hand, varieties such as Seedway48 and 9325 showed low fruit size and the lowest total yield. With respect to BER, varieties such as SWBO001, Boca and Prowler had less than 10% of BER incidence. Higher incidence of BER was noted for Seedway 48, SV3255 and Playmaker and ranged from 25 to 31%. Knowledge of calcium accumulation during fruit development will help to develop effective management strategies to minimize BER. We therefore quantified the amount of calcium in different sections of the fruit (distal, mid, and proximal) and at different fruit developmental stages. Results showed that calcium concentration and accumulation do not differ in proximal, mid and distal sections of the fruit. Further calcium accumulation in fruit increase during development. Further studies will be focused to understand the role of calcium and their relation to BER in susceptible and tolerant varieties.

The Effect of Environment and Nutrients on Hydroponic Lettuce Yield, Quality, and Phytonutrients

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In response to increasing interest in greenhouse production and difficulties imposed by adverse environmental conditions in the southeastern United States, a study was conducted with green and red-leaf lettuce cultivars grown in a deep-water culture production system. Plants were seeded in Rockwool and germinated under greenhouse conditions (Verona, MS; 34° N Lat.) at 25/20 °C (day/night) for 21 days before transplanting. The experimental design was a randomized complete block with a 2 x 3 factorial arrangement of cultivar and nutrient treatments that consisted of six replications, with individual tubs representing an experimental unit. Treatments consisted of two lettuce genotypes 1) green (Winter Density) and 2) red (Rahazes) and three nutrient treatments containing electroconductivity (EC) levels of 1) 1.0 mS·cm−1, 2) 2.0 mS·cm−1, and 3) 4.0 mS·cm−1. After 50 days, plants were harvested, processed, and analyzed to determine marketable yield, biomass, plant height, and stem width. Nutritional quality was assessed by determining flavonoid and phenolic content and leaf elemental nutrient concentrations. Project results demonstrated that the interaction between growing season and lettuce cultivar was the predominant factor influencing yield, biomass, and plant quality. Nutrient solution EC treatment significantly affected shoot dry mass, biomass, and water content. EC treatment also significantly impacted the concentration of 3-O-glucoside and uptake of phosphorous, potassium, iron, boron, zinc, and molybdenum. Results from this study indicate that the effects growing season and cultivar on leafy lettuce performance (yield and quality) was more pronounced than the effect of nutrient solution EC treatment. However, despite statistical insignificance all elemental nutrients increased with increasing solution EC. Thus, greenhouse production of green and red-leaf lettuce cultivars in the southeastern, United States should be conducted in the spring and fall growing seasons with elevated nutrient solution EC of ≈4.0 mS·cm−1 to maximize yield and quality. The current study may spur research into the performance outcomes of increasing individual solution nutrients in conjunction with production season and green and red-leaf lettuce cultivars.

Yield Performance of Organic Vegetables Grown in ‘Drip Organics’ Vertigro System

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Vertical farming is gaining attention in urban communities to grow fresh food locally. As such vegetables are grown vertically in small unit areas to large acres of land. Fifteen varieties of organic vegetables were evaluated in outdoor vertical towers at the organic farm of Tennessee State University in Nashville. Towers were spaced 5’ apart and 3’ in-row with five Styrofoam pots stacked per tower and a nutrient pot on the top. Each tower contained 22 plants (4 plants/pot) and a total of 198 plants in a 75-ft² area. Organic nutrients supplied by drip in stacked pots from top nutrient pot to bottom. Coco fiber and perlite media used in the pots to support plants. Results showed that the model and varieties were significant (P < 0.05). In Tomato, (var. ‘Moskovitch’) produced the highest yield reaching 1,335 g/plant followed by var. ‘Tango’ with a yield of 600 g/plant. Collard green (var. ‘Champion’) had the highest yield (111 g/plant), followed by var. ‘Georgia’ Collards (55 g/plant). In Kale, yields of var. ‘Meadowlark’, ‘Lacinto’ and ‘Westlander’ were 62.8 g/plant, 47.6 g/plant and 43.7 g/plant respectively. Lettuce provided the highest yield (176 g/plant) followed by ‘Romaine’ (74.8 g/plant). In Spinach, var. ‘Summer’ produced a yield of 34 g/plant. In Mustard, var. ‘Giand Red’ produced 55 g/plant. In Swiss Chard, var. ‘Fordhook Giant’ yield was 13.6 g/plant. While in Pepper, var. ‘Green Chile’ produced 137.5 g/plant, yield in Eggplant was 725 g/plant. No incidence of weeds, insect pest and disease observed.
Effects of Nutrient Solution Temperature on Growth of Greenhouse Grown Lettuce (Lactuca sativa L.)

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Greenhouse vegetable production is growing in popularity across the southeast due to increased consumer demand driven by local food movements. Energy costs account for up to 30% of overall production costs for greenhouse vegetables that can consume more than 80x more energy during production than field-grown varieties. Therefore, reducing energy costs, particularly in cool months, may be the most effective way quickly reduce production costs in controlled environments. A novel way to improve production and reduce energy costs may be through heating nutrient solution in conjunction with, or as opposed to, heating air. Water has more than 4x heat capacity of air, thus retains heat longer. It is unclear in the literature how much effect heating nutrient solution has on growth characteristics of greenhouse-grown lettuce. In a series of experiments, we grew Rex lettuce (Lactuca sativa L. ‘Rex’) at differing nutrient solution temperatures in both deep water and nutrient film technique systems to compare growth to unheated controls. In deep water culture, lettuce grown in nutrient solution heated to a target temperature of 22 °C had 14% higher head fresh weight than lettuce in an unheated solution. In a separate experiment, we identified 26.9 °C as the optimum temperature for lettuce nutrient solution that would lead to an expected head fresh weight increase of 41%. Finally, growing lettuce in a nutrient film technique system in nutrient solution heated to a target temperature of 24 °C led to a 127% increase in head fresh weight compared to an unheated control.

A Comprehensive Economic Analysis of Grafted Tomato Production in High Tunnel and Open Field Systems

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Although the benefits of using grafted plants for improving tomato production have been increasingly recognized, the high cost of grafted transplants still remains a major concern among growers. In this study, a partial budget analysis was conducted to compare the profitability of grafted ‘Tribute’ and ‘Garden Gem’ tomato production with non-grafted tomato production in both open field and high tunnel systems. The on-station trial was conducted on certified organic land in Citra, FL, during the Spring 2016 season. Transplant cost estimation showed that the average cost of grafted transplants was about three times that of non-grafted transplants. Grafted tomatoes of both cultivars resulted in higher yields than the nongrafted tomatoes, which led to improved gross return, but also increased the harvesting cost. However, even with the elevated transplant and harvesting costs, grafted tomatoes still generated higher economic return under both high tunnel and open field production. Compared to the non-grafted tomatoes, the added net return of grafted ‘Tribute’ and ‘Garden Gem’ in open field was about $8,552/acre and $4,348/acre, respectively. The added net return of grafted ‘Tribute’ and ‘Garden Gem’ under high tunnel production was about $23,061/acre and $13,273/acre respectively. Results from this study indicated that the economic benefit of grafted tomatoes was more pronounced in the high tunnel production system in comparison with open field production, primarily due to the greater impacts of grafting on improving plant growth and fruit yield in high tunnels. The economic feasibility of grafted tomato production also depends on tomato cultivar and market price.

Pollination and Maternal Effects on Fruit Shape Traits in Capsicum annuum L.

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Our current “Building Better Peppers” program aims to develop pepper varieties improved for fruit quality traits. Fruit color, shape and, pericarp thickness of pepper fruit are commercially important traits. In order to understand the inheritance of fruit quality traits, we studied ‘Miniature chocolate’ and ‘Sweet Pickle’ differing in fruit traits, ‘Miniature Chocolate’ was crossed to ‘Sweet Pickle’ pollen and ‘Sweet Pickle’ to ‘Miniature Chocolate’ pollen. Multiple fruits collected from both parents and F1 were harvested and evaluated. The results showed that fruit of F1, ‘Sweet Pickle’ × ‘Miniature Chocolate’ had a higher pericarp thickness value than its reciprocal cross, suggesting that there was a pollen effect for this trait. Fruit of F1, ‘Miniature Chocolate’ × ‘Sweet Pickle’ had a significantly higher color space “a value” than fruit from its reciprocal cross. Fruit of F1, ‘Miniature chocolate’ × ‘Sweet Pickle’ had higher perimeter, fruit shaded area and curved width than fruit from its reciprocal cross, suggesting maternal effects on fruit shape.

POSTERS

—Education—

The Auburn University Aquaponics Initiative: Leveraging University Resources to Enhance Teaching and Research

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In Fall 2015, faculty representing four departments in Auburn University’s College of Agriculture formed a partnership initiative with the office of Campus Dining to provide fish and vegetable produce from a model aquaponics system for the...
Auburn University community. In addition, the initiative has provided interdisciplinary research, extension, and teaching opportunities for faculty and students. In the partnership, Campus Dining provides support for operational costs of the pilot-scale aquaponics system, including fish feed, plant seeds, containers, substrate, and harvesting equipment, energy, and labor. In return, all produce from the system is delivered to on-campus dining facilities. The support provided by the Campus Dining office allows the system to be operated at a much larger scale than is normally possible for research, teaching, or extension projects and allows researchers to capture more accurate data. The ultimate goal of our research team is to develop the aquaponics technology to a feasible industrial scale by maximizing secondary and tertiary revenue-generating production processes that integrate well with and support the primary aquaculture process. Thus far, this partnership has not only provided high-quality protein and vegetables to the Auburn University community but has also led to three successful USDA-NIFA research grant proposals and has allowed for novel, interdisciplinary teaching and extension activities. We hope to continue and expand this partnership and believe that faculty from other land-grant universities in the southern region can develop similar, successful initiatives.

Student Attendance, Reported Study Time, Major and Mid-term Grades as Predictors of Final Course Grades Across Seventeen Years of Undergraduate and Graduate Plant Materials Courses

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Data was collected from four plant materials courses over seventeen years, two at the undergraduate level, Trees and Shrubs for Sustainable Built Environments (HORT 306) and Plants for Sustainable Landscapes (HORT 308), and two at the graduate level, Plants for Landscape Design (HORT 608) and Plants for Landscape Design II (HORT 609), and analyzed for trends in student performance and benchmarks which might be associated with student success. Data included student enrollment, midterm grades, final grades, number of unexcused absences, student reported study times for various activities, student major, student experience (class rank), whether the courses were required or not, and perceived difficulty levels of the courses. Trends in grade distributions were fairly stable until the last three to four years when mean final grades and the frequencies of A or B grades increased, probably due to changes in grading and assessment procedures. Midterm grades were highly predictive of final course grades in all four courses with $R^2 = 0.91, 0.77, 0.64$, and $0.64$, for HORT 306, HORT 308, HORT 608, and HORT 609, respectively, at $P \leq 0.001$. The only other benchmark significantly associated with final course grades were the number of unexcused absences which were all negatively correlated at $R^2 = -0.54, -0.42, -0.50$, and $0.50$, for HORT 306, HORT 308, HORT 608, and HORT 609, respectively, at $P \leq 0.001$. Lesser changes between midterm and final grades were observed for fall than spring courses, particularly for seniors.

Self-reported time spent studying was not correlated ($P \geq 0.05$) with final course grades. Perceptions of courses as moderately difficult on average (7.3–8.0 out of 10.0) were remarkably stable overall, but varied considerably by major, means of 5.3–8.4, and experience, 7.3 for seniors to 8.1 for freshman.

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Floriculture, Ornamentals & Turf—
Long-term Effects of Compost on Landscape Soils and Performance of Warm-Season Annuals

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Gardens were created at the Rockwall County, TX, courthouse and divided into four beds, each subdivided into two planting areas, one with 7.5 cm of compost only (CO) and a second fertilized with a slow-release (SR) fertilizer at 129 g·m$^{-2}$ (Osmocote Plus 15–9–12, 6-month). Planting areas were separated using steel edging and a 30 cm buffer zone. Each planting area was randomly planted with three plants of seven warm-season annual cultivars. Beds were tilled and replanted each May for three growing seasons, and SR was added but no additional compost. All beds were mulched with 7.5 cm of shredded hardwood bark. Plants were watered as needed. Visual foliage and flower quality ratings were collected monthly using a 0–10 scale. Drought, disease, and pest tolerance were scored by estimating the percentage of the plant without injury. Each October, plant size was measured, and shoots removed and dried at 70 °C for 72 hours to determine fresh and dry shoot mass. Soil samples were collected for soil physical and chemical properties. Soil bulk density, total pore space, water content and soil organic matter were statistically similar ($P \leq 0.05$) for both CO and SR bed treatments, though dramatically different from native soil conditions. Soil N, P, K, and Cu were higher in SR beds, while other plant nutrients were similar, likely due to the high natural fertility of the native Houston Black clay soil. Flower and foliage ratings were higher for ornamental peppers, celosia, and portulaca in SR beds, while ratings were similar in both bed treatments for vinca, gomphrena, and pentas. Zinnias quickly overgrew in fertilized plots, and ratings were higher in compost plots. Celosia, gomphrena, and portulaca were larger when fertilized, but all others were similar. Though fertilized plants did result in higher quality and larger plants for many species, mature, composted landscape beds do maintain good fertility and make possible good plant performance for selected cultivars.

Integration of Nursery Production and Propagation Learning Experiences in a Multidisciplinary LID Landscape Project Yields Academic and Economic Benefits

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S481
Stormwater management strategies, such as Low Impact Development (LID), are increasingly utilized in sustainable development, to minimize adverse impacts of runoff from impervious land cover or to reduce non-point source pollution loads. Uniformly distributed facilities such as bioretention stormwater collection devices, filtering systems, and water reuse mechanisms are used to reduce runoff. Hands-on activities involving design, installation, monitoring, management, and evaluation of stormwater management designs are components of a project undertaken by a multidisciplinary group involving faculty and students from Landscape Architecture and Urban Planning, Horticultural Sciences, and Civil Engineering. In the first two years of the project over 300 students have been involved. One key horticultural component has been growing the vast majority of plants for the project from seeds, rooted cuttings, or small liners to sizes ranging from 4” pots to a 100 gallon tree. These activities have resulted in extensive high impact learning activities for numerous students as well as contributing an estimate $26,258, wholesale value of plants for use in this on-campus improvement and demonstration project. Wholesale values were estimated from industry databases in Fall 2017. Retail values were estimated to exceed $50,000. These research and learning activities were funded by a Texas A&M University Tier One Program (TOP) Grant and the Aggie Green Fund, and conducted in part in facilities supported by Hatch Funds from the National Institute of Food and Agriculture (NIFA).

Leaf Temperature, Photosynthesis, and Stomatal Conductance in Dark Foliaged Crape Myrtles in North Texas

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Dark foliaged crape myrtles (‘Ebony’ cultivars, often sold as Black Diamond®) are relatively new to the industry, and performance evaluations have given mixed results during the heat and drought of a North Texas summer. The presence of dark pigments, typically anthocyanins, is beneficial to some plants but may decrease net photosynthesis (Pn) in others during heat stress. This study was conducted to compare leaf attributes related to A between dark and green leaf crape myrtles. The study used twenty four crape myrtles planted at three locations with varied soil types, the A&M-Commerce Plant Science Center (PSC) (silt loam, pH 7.1), the A&M-Commerce Blueberry Farm (BBF) (loamy sand, pH 5.2), and the Greenville Sports Park (GSP) (clay, pH 8.2). Plants were maintained with minimal input, with no fertilization, no irrigation in 2016 or 2017, no pest or disease control, and no pruning throughout the study. In Aug. and Sept. 2017, an LI-6400xt portable photosynthesis system was used to measure leaf temperature (°C), Pn, and stomatal conductance (g). Readings were allowed to stabilize within the chamber, and one set of readings was taken for each plant at each location. Readings were taken between 10:00 am and 4:00 pm each day. High temperatures on recording days were 35, 35, and 29 °C, and readings were taken during clear or partly cloudy conditions. Leaf temperatures at GSP (26.2 to 26.6 °C dark, 26.6 °C green) and PSC (35.8-36.4 °C dark, 36.6 °C green) did not differ between cultivars of different leaf color. Leaf temperatures at BBF were higher (32.4 °C) in ‘Ebony and Ivory’ and ‘Ebony Fire’ (31.8 °C) than other dark cultivars (31.0 to 31.4 °C) and green cultivars (31.1 °C). No differences were found in Pn or g, amongst the various cultivars. While these dark foliaged crape myrtles do not appear to perform as well as a green leafed cultivar under heat and drought stress, the researchers find no data to suggest that performance is related to leaf physiological performance.

Effects of Foliar Compost Tea and Select Application Methods of Auxin on Rooting of Softwood Rose (Rosa ‘Old Blush’ Jacq.) cuttings

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As consumer interest in organic production techniques increases, research on these techniques/products and their purported benefits should be conducted. One such product is compost tea (a brewed extract of compost). Interest in the use of compost tea in agriculture has increased as it offers a potential broad-spectrum, organic control for pathogenic microbes. The current research was designed to test the effect of the aerobic compost tea on rooting percentage and the overall size of the root system in rose cuttings (Rosa ‘Old Blush’ Jacq.). Cuttings were also treated with varying concentrations of auxins that were applied as either liquid or talc-based formulations. Cuttings treated with compost tea and the liquid auxin formulation rooted at a lesser percentage (59.2%) than the non-tea treated cuttings (76.6%) when they were also treated with the liquid auxin formulation. No other compost tea treatment significantly influenced rooting percentage or root system size of the ‘Old Blush’ cuttings. Significant effects of auxin concentration and formulation of auxin were observed for rooting percentage and all of the root system size measurements. Cuttings treated with the talc-based, 1000 mg·L⁻¹ concentration of auxin generally rooted at greater quantity and with larger root systems than any other treatment observed.

Hardwood Cutting Propagation of ‘Pascagoula’ Crape Myrtle

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Crape myrtles are a reliable source of color in many southern landscapes, and the cultivar palette is constantly expanding. Mississippi State University has been active in the development of new crape myrtle selections, including ‘Pascagoula’. This new crape myrtle has a deep purple flower color and small to medium growth habit. Flowering occurs from early June through late August. The objective of this research was to determine optimal commercial auxin formulation and concentration for hardwood cutting propagation of ‘Pascagoula’. Cuttings (12.7-cm medial) were harvested from the parent plant and stuck to a depth of 2.5 cm on 1 Feb. 2017. Propagation medium was 100% perlite placed in 7.6-cm containers. Treatments included two basal treatments (wounded or non-wounded), three auxin formulations [Hortus IBA (Hortus IBA Water Soluble Salts), Dip’N Grow, or Hortus IBA + KNAA (Hortus IBA Water Soluble Salts + NAA potassium salt)], and three levels of auxin (0, 1000, or 5000 ppm IBA). Dip’N Grow and Hortus IBA + KNAA formulations contained NAA at one-half the rate of IBA. The experimental design was a randomized complete block design with five single cutting replications. Data collected after 60 days included rooting percentage, growth index (new shoots), cutting quality (0–5, with 0 = no roots and 5 = transplant-ready cutting), total root number, average root length (of three longest roots), and root quality. Data were analyzed using linear mixed models and generalized linear mixed models with the GLIMMIX procedure of SAS (ver. 9.4; SAS Institute Inc., Cary, NC). Treatment had no effect on rooting percentage. However, plants treated with 5000 ppm Hortus IBA + 2500 ppm KNAA had a higher root count compared to plants treated with 1000 ppm Hortus IBA + 500 ppm KNAA. Wounding resulted in a 1-cm greater average root length compared to average root length of non-wounded cuttings. Regardless of rate, treatment of cuttings with Hortus IBA + NAA resulted in a lower root quality rating when compared to cuttings receiving no auxin treatment, but cuttings treated with 5000 ppm Hortus IBA + 2500 ppm KNAA did have a higher root quality rating when compared to cuttings treated with Hortus 1000 ppm IBA + 500 ppm NAA. Cutting quality was similar for all treatments. These results suggest that hardwood cuttings of ‘Pascagoula’ crape myrtle may be successfully rooted without wounding or the use of auxin.

Trace Gas Emissions from a Sun- and Shade-grown Ornamental Crop

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Previous work has begun to establish baseline approximations for greenhouse gas (GHG) (CO2, CH4, and N2O) emissions of several horticultural crops, though much work is still needed to expand contingencies for multiple best management practices. In this study, GHG emissions from one shade-grown species, ‘Royal Standard’ hosta (Hosta × ‘Royal Standard’), and one sun-grown species, ‘Stella D’Oro’ daylily (Hemerocallis × ‘Stella D’Oro’), were evaluated in standard bark-based substrates with one of three fertilizer methods (dibbling, incorporated, or top-dressed) (25 g/container of Polyon 16–5–10, 12-month release + micros). Plants were grown in 3.5-L (1-gallon) nursery containers, and irrigated with overhead irrigation calibrated to deliver 6.35 mm (0.25 in) water three times daily. Gas samples were collected in situ once weekly over a 5-month period (23 Apr. to 24 Sept. 2015) using the static closed chamber method according to standard protocols and analyzed using gas chromatography. Both CO2 and N2O total cumulative efflux was least for plants fertilized with the dibbled method, regardless of species. Total cumulative CO2 emissions were greatest for both daylily and hosta with incorporated fertilizer, though in the case of the sun-grown daylily, CO2 efflux was similar among plants with fertilizer that had been either incorporated or top-dressed. There were no differences in N2O efflux for both the incorporated and top-dressed treatments of shade-grown hostas and sun-grown daylilies. Methane (CH4) efflux was consistently low throughout the study. Commensurate with previous work, daily CO2 and N2O emissions experienced a spike at study initiation. In general, daily CO2 efflux was greater for shade-grown hosta than for daylily, while initial spikes in daily N2O emissions were greater for sun-grown daylily than for shade-grown hosta. Findings suggest that utilizing a dibbled fertilizer placement could significantly decrease both CO2 and N2O emission.

Wood Fiber as a Substrate Component in Vegetative Propagation of Euphorbia pulcherrima

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Rooting of Euphorbia pulcherrima ‘Freedom Red’ was evaluated in four substrates, two of which contained HydraFiber 160WB, a high wood content substrate, as a perlite replacement. Treatments consisted of an 80:20 (v:v) blend of peat:perlite, a 70:30 (v:v) blend of peat:perlite, a 70:30 (v:v) blend of peat:HydraFiber 160WB, and a 50:50 (v:v) blend of peat:HydraFiber 160WB. Dolomite lime, at a rate of 3 lb/yd2 for all but the 50:50 (v:v) blend of peat:HydraFiber (which contained lime at a rate of 2 lb/yd2), was incorporated prior to sticking cuttings. Unrooted cuttings of ‘Freedom Red’ poinsettia were stuck on 15 Aug. 2017. Substrate pH and EC was evaluated at 0, 15, and 29 DAP. Root and shoot dry weight were measured at study termination (29 DAP). Substrate main effects were significant at P < 0.05 for pH across all dates, and for shoot dry weight at termination. The pH was highest for the 70:30 peat:perlite treatment, while all other treatments were statistically similar. Root weight at termination was similar across all substrate treatments. For shoot dry weight at termination, both 50:50 peat:HydraFiber 160WB and 70:30 peat:HydraFiber 160WB substrate treatment were similar to 80:20 and 70:30 peat:perlite industry standards. Based on results from this trial, up to 50% HydraFiber may be acceptable as a rooting substrate component for Euphorbia pulcherrima.
—Fruit Crops—

An Efficient Method for Introducing Wild Blueberry from the Southeastern United States to In Vitro Conditions for Micropropagation

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Wild blueberry species (Vaccinium spp.) have been used in breeding southern highbush blueberry (SHB, V. corymbosum interspecific hybrids) because of their interspecific cross compatibility, abiotic stress tolerance, and desirable fruit characteristics. Additionally, wild Vaccinium spp. are indicators of intact, high-biodiversity ecosystems in the southeastern United States. Nevertheless, vegetative propagation of wild Vaccinium spp. is not easily accomplished. Micropropagation might be an alternative for producing large numbers of pathogen-free plants. Here we present an efficient method for introducing wild blueberry species to in vitro conditions for micropropagation. Softwood cuttings of V. arboreum genotype FL09-502, V. elliottii genotype FL16-662, V. myrsinites FL16-661, and V. darrowii genotype FL08-436 were used as explants. SHB ‘Farthing’ and SHB ‘Emerald’ were used as controls, as there are micropropagation protocols optimized for SHB. We tested three different tissue ages. Healthy, non-lignified branches were visually classified as young, medium, and mature. Explants were rinsed in tap water with two drops of Tween 20. Following, explants were vortexed in 70% ethanol for 1 minute, 20% bleach for 20 minutes, and, finally, rinsed three times in sterile water. Subsequently, explants were transferred to initiation “medium a” as per Litwinczuk et al. (2003). Young explants exhibited significantly higher oxidation rates than medium and mature explants. Microbial contamination was the most common reason for failure of medium and mature explants. In a subsequent experiment, we tested three different disinfection pre-treatments applied 72 hours before explant collection: control (H2O), contact fungicide (Captan 1 g/L), and a combination of contact and systemic fungicides (Captan 1 g/L + Chlorothalonil 0.89 g/L). Explants pre-treated with the combination of contact and systemic fungicides exhibited significantly lower contamination rates than all other pre-treatments (21% versus 45% and 57%). Using the best tissue age and pre-treatment, introduction success rates were 21% versus 45% and 57%). Using the best tissue age and pre-treatment, introduction success rates were 21% versus 45% and 57% (21% versus 45% and 57%).

Influence of Maturity on Physicochemical Quality of Genomically Diverse Banana (Musa spp.) Cultivars from Southeastern United States

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Banana (Musa spp.) is the fourth most important food crop after rice, wheat, and maize consumed across the world. Optimum ripening is required to maintain the quality of the fruit and good market price, followed by correct handling and processing of the fruit. The current study was designed to determine the effects of maturity on physicochemical quality of genomically diverse banana cultivars in the southeastern United States. The pH, titratable acidity (TA), soluble solid content (SSC), and SSC/TA ratio (sweetness) of six banana cultivars different in genome including FHIA1 (AAAB), Hua Moa (AAB), Kandarian (ABB), Pisang Raja (AAB), Saba (ABB), and Williams (AAA) were determined during four maturity stages (i.e., mature green, transition, fully ripe, and over ripe). The lowest values of pH and the highest values of TA were observed in fully ripe stages of all cultivars. The SSC and SSC/TA increased significantly during ripening from mature green to over ripe stage. Fully ripe fruits of ‘Williams’ were reported as the sweetest fruits with the highest value of SSC/TA among the other cultivars and stage of maturities. This study provides a useful guide for postharvest handling and packaging of bananas of similar maturity and characteristics for commercial practices.

Salt Exclusion and Alkaline Soil Tolerance of Common Muscadine and Rootstock Cultivars

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Bunch grapes (Vitis spp.) are classified as moderately salt tolerant. However, little is known about the salt tolerance of muscadine (Vitis rotundifolia) grapes. The objective of this research is to evaluate the salt exclusion capacity of muscadine grapes relative to common bunch grape rootstocks and own-rooted hybrids. In two separate experiments, 33 muscadine, 6 bunch grape rootstock, and 3 own-rooted hybrids were irrigated daily with a 25 m NaCl salt solution for a period of 14 days and destructively harvested to determine Na+ and Cl− concentrations in roots and shoots. Immediately prior to harvest, leaf necrosis was rated on a scale of 0–4. In experiments one and two, leaf necrosis ratings ranged from 0.17–2.08 and 0.08–2.33, respectively, across all cultivars. The highest ratings were observed in 1103 ‘Paulsen’ (P), a common bunch grape rootstock followed by ‘Victoria Red’, a Pierce’s disease tolerant hybrid commonly grown on its own roots. In both experiments the muscadine cultivars ranked lower than 1103P, ‘Victoria Red’, 420A, and ‘101-14 Millardet et de Grasset’ (Mgt). To evaluate the relative alkaline soil tolerance of muscadines, 33 muscadines cultivars, 6 bunch grape rootstock cultivars, and 3 own-rooted hybrids were evaluated under field conditions in an alkaline (pH 8.2) Weswood silt
loam soil. At the end of the growing season, tissue samples were collected from each cultivar for nutrient analysis. SPAD data was collected on basal, proximal, and apical leaves, and visual chlorosis ratings were taken. Chlorosis ratings ranged from 1 to 1.6 across cultivars. ‘Victoria Red’ had the highest chlorosis rating followed by nine muscadine cultivars. However, there was not a consistent difference between muscadines and bunch grapes. Across muscadine cultivars, significant differences in visual chlorosis were observed. Additional research will be necessary to determine the relative alkaline soil tolerance of muscadines compared to bunch grapes and across muscadine cultivars. Tissue analysis results are pending.

**Measuring Water Stress in Peach Trees: Soil Moisture versus Tree Water Movement**

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When concerning peach tree irrigation, there is a lack of information on tree water needs for the southeastern United States, in part as a consequence of the daily fluctuations of its humid subtropical climate. The objective of this study was to improve the usage of soil sensors (tensiometers) by comparing their readings at 6", 12", and 24" with tree measurements taken with dendrometers that measure micro-variations in the tree trunks caused by movement of water. The maximum daily shrinkage value (MDS) can be calculated by the difference between the daily maximum and minimum trunk diameter. Previous studies have showed an excellent correlation between MDS and tree water needs. This experiment was carried out in the field with three-year-old peach trees and two treatments were applied: 1) well-watered trees (control) and 2) trees under water deficit (receiving 1/3 of the control trees). Data showed that the variability of the MDS value of the trees under water deficit was remarkably higher than that of the well-watered trees. Nevertheless, the daily fluctuating environmental conditions of South Carolina, especially relative humidity and temperature, seemed to be the main challenge to correlating values between the dendrometers and the tensiometers. Tensiometers deeper than 12" did not correlate to the tree-based sensors at all. Further monitoring is needed to explore the conditions and their effects on these sensors to better understand the correlation.

**Fruit Firmness and Susceptibility to Splitting and Spotted-wing Drosophila on Different Grape Cultivars**

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Fruit splitting is a physiological disorder that promotes disease and insect damage via surface cracking of the skin. This type of damage could be an entry site for the spotted wing Drosophila (SWD), *Drosophila suzukii*, a species of vinegar fly that attacks various berry crops, including grapes, and reduces fruit quality and yield. In this study, we tested susceptibility of various hybrid bunch grapes and muscadines to berry splitting and SWD infestation. Ten grape cultivars were harvested in 2017 from experimental plots and one was purchased locally. Fruit quality traits measured included Brix (% sugar content), total acidity (TA), pH, fruit firmness, and skin break force. ‘Thompson Seedless’ was the most susceptible to berry splitting, whereas ‘Villard Blanc’ and ‘OK-392’ were the least susceptible. Although muscadines showed the highest firmness, some were also highly susceptible to splitting, especially ‘Fry Seedless’. No significant correlations were found among sugar content, firmness and splitting; however, there was a negative correlation between splitting and TA. Based on our findings, ‘Thompson Seedless’ was the only truly susceptible host of SWD. The hybrid grapes appear resistant or highly tolerant of SWD. SWD females do not seem capable of ovipositing in host fruits that require a skin break force exceeding 300 N. Wounds or splits in the grape epidermis increased reproductive success of SWD by 400%. Vineyards suffering fruit split damage might provide SWD with a host, but overall the hybrids and muscadines we tested were tolerant of SWD.

**Optimizing Fertilization Rates for Young Peach Orchards in the Southeastern United States**

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Providing general fertilization recommendations for peach tree orchards valid for an entire region is challenging and may not be accurate as peaches are grown under different climates and soil conditions. In this field study, the effects of different fertilization treatments were assessed during the first three years of a peach orchard with two varieties: ‘Juneprince’ and ‘Scarletprince’. Three treatments were used: 1) traditional, fertilizer applied in March, May and July at rates described in regional guidelines; 2) split, same amount of fertilizer as in the traditional treatment but split monthly between March and July; and 3) reduced, same amounts and timings as split treatment but without the last application in July. As a consequence, trees in the reduced treatment received 30% less fertilizer than in those in the traditional or split treatments. Results showed that there were no differences in growth (tree trunk cross-sectional area) among treatments. Nitrogen and potassium concentration in the leaves were similar for all treatments at the end of the third year (July) for both varieties. Because of freeze events in 2017, yield data was only collected in one variety (‘Scarletprince’) and no significant differences were found neither in yield nor in yield efficiency among treatments. Thus, these results show that remarkable amounts of fertilizer could be saved and orchard sustainability and profitability could be improved if fertilizer rates are optimized for specific fruit tree growing areas.
Size Controlling Rootstocks for Enhanced Sustainability of Apple Production in Alabama

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To investigate the adaptation of newly developed size-controlling and fire blight resistant apple rootstocks planted in a high-density training system in Alabama, fourteen rootstocks were evaluated for their vegetative growth, productivity and fruit quality characteristics at the Chilton Research and Extension Center (CREC), Clanton, AL. Apple rootstocks tested included V.1, V.5, V.6, V.7, G.11, G.30, G.41, G.202, G.214, G.935, G.969, M.9-337, B.10, and M.26 EMLA. 'Aztec Fuji' was the scion cultivar for the experiment established in 2014. The trees were planted in a RCBD fashion and comprised of ten replications with a planting distance of 1.52 m x 3.96 m. Trees were trained to a Tall Spindle system. Our 2017 results indicate a significant rootstock effect on ‘Aztec Fuji’ vigor and total yield/tree. ‘Aztec Fuji’ trees grafted on G.969 produced the highest yield of 14.0 kg/tree, while M.26 EMLA rootstocks produced the lowest crop of 4.2 kg/tree. Trees on V.6 were the most vigorously growing based on data for trunk cross-sectional area. Trees on V.7 produced the largest fruit size, followed by trees grafted on G.935, but no rootstock effect was accountable for ‘Aztec Fuji’ fruit size. Rootstock studies will continue to evaluate the scion responses in multiple seasons for a more complete assessment of the system efficiency and sustainability in Alabama conditions.

Do Strawberry Growers Meet Current Recommendations for Spring Plant Tissue Nutrient and Petiole NO$_3$ Concentrations in Arkansas?

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Sufficient ranges of major nutrients in strawberry leaf tissues and NO$_3$-N petioles at different phenological stages of the crop have been established, and are used for early spring crop nutrient status monitoring programs in order to maintain high yields and fruit quality. These standardized ranges have been in place for nearly 20 years; however it is not known how often growers meet these recommendations, or how effectively they use test results to amend their fertilizer practices. Over twelve weeks in the spring of 2017 strawberry leaf tissue and petiole nutrient results submitted to the Arkansas Agricultural Diagnostic Laboratory in Fayetteville, Arkansas were collected and analyzed. Data on leaf Nitrogen, Phosphorus, Sulfur and Boron (ppm) and petiole NO$_3$-N (mg/kg) from 136 samples consisting of 15–20 leaves and petioles were collected. In addition the strawberry crop growth stage, variety, location and bloom stage were recorded for each sample. Samples were collected from 20 growers and Chandler made up 87.5% of samples collected. Scatterplots and averages of nutrient results were compared to recommended ranges for plant nutrient content based on data collected on phenological crop stage. Throughout the 12-week period, the majority (> 75%) of samples had leaf tissue sulfur and potassium contents within recommended ranges. Leaf nitrogen and boron contents were below the recommended ranges for 37.9% and 21.9% of the samples respectively. In 63% of the samples petiole NO$_3$-N concentrations below the optimum range during weeks 1-4. During week 5, 16.5% of samples remained below optimum levels of petiole NO$_3$-N while 67% were within optimum levels. Since petiole NO$_3$-N is a measure of nitrogen actively being taken up by the plant, and leaf tissue N is a measure of assimilated N, low petiole concentrations of NO$_3$-N measured early on in the season are directly related to low leaf N concentrations. By weeks 6 to 9 of the sampling period 85% of the samples were within the recommended petiole NO$_3$-N concentrations, while only 2% were above and 13% were below recommended levels. These results indicate that Arkansas growers do not currently meet recommendations for petiole NO$_3$-N concentrations in the first four weeks of the season (bloom stage of growth) and should increase early season Nitrogen applications or more quickly respond to test results to improve crop yields. Some growers should increase applications of spring applied boron

---Vegetable Crops---

A Rapid Approach for Salt Tolerance Evaluation in Cowpea at Seedling Stage

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Salinity is a major constraint affecting crop production globally. Seedling is a stress-susceptible stage in plant growth and development. Impacts of salinity on cowpea have been demonstrated to be yield reducing. Developing a rapid approach for screening salt-tolerant cultivars will help cowpea breeders to screen a large population in a relatively short period of time, thus contributing to enhancing breeding programs. Therefore, the objective of this study was to develop a rapid methodology to evaluate salt tolerance in cowpea at seedling stage in order to discriminate the salt-tolerant genotypes from the susceptible ones. A total of 30 genotypes were used in this study. Two genotypes, PI582468, salt-tolerant, and PI255774, salt-susceptible, as previously reported, were used as controls for validating the methodology. The experiment was completely randomized design with three replications, and organized in a split-plot manner. Salt concentration was 200 mM. In addition to the salt-treated plants, another set of plants was irrigated with deionized water. Irrigation was conducted from the bottom of the pots in which cowpea genotypes were planted in order to assist plant roots in rapidly taking up salt compounds. Salt treatment was initiated at the beginning of V1 stage, and carried out daily for two hours until the susceptible check was completely dead. The analysis of variance (ANOVA) was performed using JMP® Genomics 7. Results revealed significant differences among the 30 genotypes in average number of dead plants per pot, leaf injury scores, relative salt tolerance for chlorophyll, plant height, and leaf and stem biomass (P-values < 0.0001). All PI255774 plants were completely dead, whereas
those of PI582438 were fully green after two weeks of salt stress. In addition, a highly salt-tolerant genotype, PI349674, was identified. Relative salt tolerance for chlorophyll content was highly correlated with number of dead plants and leaf injury scores (r = -0.77 and r = -0.79, respectively), indicating that the higher the number of dead plants were, the lower relative salt tolerance for chlorophyll content and leaf injury scores were. Relative salt tolerance for leaf biomass was moderately correlated with number of dead plants and leaf injury scores (r = -0.46 and r = 0.50, respectively), whereas relative salt tolerance in plant height was poorly correlated with number of dead plants and leaf injury scores (r = 0.11 and r = 0.17, respectively). Therefore, number of dead plants per pot, chlorophyll content, and leaf injury scores were good criteria for salt tolerance evaluation in cowpea. This study provided a rapid methodology and suggested simple criteria to evaluate salt tolerance at seedling in cowpea.

**Thirst Quenching: Improving Tomato Water Use Efficiency through Grafting**

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The following study was conducted to address water use efficiency in grafted tomatoes in a real-world, on-farm environment. The commercial rootstocks Beaufort and Shield were chosen as these two have different root system morphologies that may benefit water use efficiency. The heirloom cultivar Cherokee Purple was grafted onto both rootstocks as well as utilized as the non-grafted control. The study was conducted in 2016 and 2017 on a sustainable five-acre vegetable and cut flower farm in North Carolina’s Piedmont region. Plants were grown under protected, high-tunnel culture where they received either 100% (3 h every other day) or 50% (1.5 h every other day) of the grower’s normal irrigation regime. The ‘Beaufort’ grafted plants significantly improved irrigation water use efficiency (iWUE) at the 50% irrigation treatment compared to the other rootstock treatments. Furthermore, at 50% irrigation, ‘Beaufort’-grafted plants yielded significantly more than all other rootstock treatments at 50% irrigation as well as the non-grafted ‘Cherokee Purple’ receiving the 100% irrigation treatment. Regardless of irrigation treatment, grafting onto ‘Beaufort’ improved the quality of total fruit harvested. An economic assessment was conducted to determine the feasibility of utilizing grafted plants in conditions lacking significant disease pressure. Purchasing grafted transplants would increase the initial investment by $60.30/100 ft. However, the increased yield obtained when utilizing the ‘Beaufort’ rootstock at 50% irrigation increased net revenue by $596.75/100 ft compared to non-grafted ‘Cherokee Purple’ receiving 100% irrigation. This amounts to an 80.7% increase in net revenue while saving approximately 4350 gallons/100 ft. Grafting tomatoes onto disease resistant rootstocks has already proven to be an effective means to manage soilborne diseases. These results indicate that growers can select rootstocks to better manage water use in an environmentally friendly manner without limiting economic gains.

**Evaluation of Commercially Available Varieties of Yellow Squash and Zucchini for Tolerance to Cucurbit leaf crumple virus in Georgia**

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The _Cucurbit leaf crumple virus_ (CuLCrV) has become a significant obstacle for fall production of Cucurbit spp. in southern Georgia. Vectored by sweetpotato whitefly (_Bemisia tabaci_) biotype B, this virus can cause significant losses in yellow and zucchini squash (_Cucurbita pepo_). Due to high populations of the virus vector during the fall growing season, virus transmission has not been able to be controlled by insecticide applications. Ultimately, resistance or tolerance to CuLCrV in commercially-available varieties will be the primary mechanism to manage this virus in Georgia. In Fall 2017, a study was initiated to evaluate 20 varieties of yellow and zucchini squash for resistance or tolerance to this virus. The study was arranged in a randomized complete block design with three replications of each variety. Each plot contained 15 plants. Plants were evaluated for virus incidence, severity of infection, vigor, and yield. All plots demonstrated 100% virus incidence within 35 days of planting. Yellow squash had a higher virus severity and lower vigor overall than zucchini squash. Yields of two yellow varieties, Lioness and Grand Prize, were significantly greater than all other yellow varieties, but were approximately one-tenth of what would be commercially acceptable for fall production in Georgia. The variety SV6009 contained 15 plants. Plants were evaluated for virus incidence, to this virus. The study was arranged in a randomized complete block design with three replications of each variety. Each plot contained 15 plants. Plants were evaluated for virus incidence, severity of infection, vigor, and yield. All plots demonstrated 100% virus incidence within 35 days of planting. Yellow squash had a higher virus severity and lower vigor overall than zucchini squash. Yields of two yellow varieties, Lioness and Grand Prize, were significantly greater than all other yellow varieties, but were approximately one-tenth of what would be commercially acceptable for fall production in Georgia. The variety SV6009 had the highest numeric yield for zucchini, with 1630 boxes/ha, although this was not significantly different than four other varieties. While yields of some zucchini were approximately one-half of what is typically observed in Georgia in fall production, they may be high enough to warrant planting if market prices are elevated. Comparison of main effects indicated that average zucchini yields were 1014 boxes/ha compared to 124 boxes/ha for yellow squash infected with CuLCrV.

**Evaluation of Spinach (Spinacia oleracea L.) Germplasm for Use In Hydroponic Production**

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Seeds of twelve commercial spinach cultivars and eleven spinach germplasm selections were evaluated for suitability for hydroponic NFT (nutrient film technique) production. Spinach germplasm were germinated in a hydroponic propagation system...
until a four-true-leaves stage. The days to germination, days to two leaves, days to four leaves, and percent germination were recorded. Eleven of the twenty-three germplasm/cultivars were carried over to the NFT production system where the seedlings remained for four weeks until harvest. Shoot fresh and dry weight, and diameter were recorded at harvest. Germplasm/cultivars ‘Bright toucan’, ‘Seaside’ and ‘15-135-Alma’ had the highest rate of germination at 96%, while ‘15-255 FY-3’ had the lowest germination rate at 7%, respectively. The germplasm/cultivars with the highest shoot fresh biomass were ‘F88-354’, ‘Emperor’ and ‘F380’. The cultivars ‘Red kitten’ and ‘Seaside’ are intended for baby leaf spinach production, and therefore had the lowest shoot fresh biomass. Under the conditions of this experiment the germplasm/cultivars most suitable for greenhouse production in a hydroponic NFT system are ‘Emperor’, ‘Seaside’ and ‘15-136 Alma’.

**Short-day onion (Allium cepa) Germplasm Evaluation for Agronomic and Disease Tolerance In South Texas**

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Onion varieties greatly adapt to growing regions due to the influence of day length. A varietal trial was conducted at Texas A&M AgriLife Research Center, Uvalde, TX, to test 108 genotypes of short day onions for bulb weight, diseases (pink root and stemphylium leaf blight) and quality traits. R-software was used to measure Pearson correlation coefficient, path coefficient and to evaluate the performance of genotypes (‘corrplot,’ “pathanalysis,” “GGEBiplots,” and “gge” packages). A significant correlation was observed for stemphylium leaf blight and pink root diseases with single center (r = 0.48, P < 0.001) and (r = 0.42, P < 0.001), respectively. Onion bulbs infected with diseases have a reduction in food storage, which could be the reason that unhealthy bulbs are not able to form more than one center. In addition, a significant positive correlation between stemphylium and pink root disease (r = 0.58, P < 0.001) suggested that reducing foliar diseases may also reduce root diseases. The highest positive correlation of bulb height with bulb weight (r = 0.69, P < 0.001) and its largest positive direct effects (0.70) on bulb weight indicated that it is the most important trait that can be selected for increasing the bulb weight. The genotypes could also be selected for higher bulb weight without sacrificing much for single center and firmness as they had small negative effects on bulb weight (–0.04 and –0.06 respectively). The onion varietal trial will be repeated next season to confirm these associations.

**Exogenous Applications of Amino Acids Affect the Growth and Concentration of Chlorophylls, Amino Acids and Sugars in Jalapeño Pepper (Capsicum annuum L.) Fruit**

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There is increasing interest on application of plant biostimulants to increase crop resistance and yield. Amino acids are involved in a plethora of cellular reactions and therefore influence a series of physiological processes such as growth and development, control of intracellular pH, generation of metabolic energy, and resistance to biotic and abiotic stresses. We evaluated the effect of concentrations of exogenous amino acids on plant growth and fruit chemical composition in jalapeño pepper. The study was conducted at the Horticulture farm, Tifton, GA, in Fall 2017. The soil was a sandy loam with a pH of 6.5. The design was a randomized complete block with four replications and four treatments (foliar application of amino acid mix BIOMIN® BOOSTER at 0.0, 2.5, 5.0 and 10.0 mL·L⁻¹). Jalapeno pepper ‘El Jefe’ was grown on raised beds (1.8-m centers) covered with white plastic mulch, following UGA Extension Service recommendations for bell pepper. The experimental plot was 7.5 m long; plants were 30 cm apart and there were two rows per bed (20 plants per plot). Results showed that plant height increased with increasing exogenous amino acid conc. Chlorophyll index and chlorophyll b content were unaffected by exogenous amino acid conc. Leaf amino acids increased with exogenous amino acid conc. Leaf soluble sugar conc. was highest with exogenous amino acids at 2.5 mL·L⁻¹. Exogenous amino acids conc. had no effect on fruit number and yield. In conclusion, although exogenous applications of amino acids increased plant height and leaf amino acid concentrations, they had no effect on fruit number or fruit yield.

**Ginger Growth Affected by Shading Treatments in High Tunnel**

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This project studied the growth and rhizome yields of three ginger cultivars [Chinese White (CW), Hawaii Yellow (HY), and Kali Ma (KM)] under shade conditions of 0%, 40%, 60%, and 80% in a 30' (w) × 96' (L) high tunnel on the farm of North Carolina A&T State University. Seed gingers were pre-sprouted in a greenhouse for nine weeks, then planted in raised beds incorporated with 20 k lb/acre compost and preplant fertilizer Weaver 17–17–17. There were two rows per bed, with in-row spacing at 6” and row spacing at 16” . One drip line was provided for each row for irrigation. Fertigation was done weekly through the drip tapes with Multi K from 7/28 to 10/31/2017. Plants were hilled once and then as needed. A split-plot experimental design was used with shade levels (not randomized) as main plots and cultivars (randomized) as split plots. All shaded ginger plants grew more vigorously and demonstrated healthier looking
from the 0% shade condition had the highest yield, followed by the 40%, 60%, and 80% shade levels. The average number of rhizome pieces per plant was in the order of, from the highest to the lowest, 0%, 40%, 60%, which was about the same, and 80%. The three cultivars were different in growth and productivity. HY grew more vigorously than CW or KM, which demonstrated similar growth. HY had the thickest stems, followed by CW then KM. The HY had taller plants than CW or KM, which had similar plant heights. Yield differences existed among cultivars although further statistical analyses need to be done to confirm significance. We also observed that only HY plants had strong aroma, which attracted caterpillars, and higher shade levels provided better frost protection to ginger plants inside the high tunnel when outside temperatures were around 25 to 28 °F.

Improving Peppers for Fruit Quality Traits: Milestones in a Project Designed to Facilitate Active Learning in Crop Breeding

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The objective of this poster presentation is to describe the milestones in a multi-year project aiming to teach plant breeding to undergraduate and graduate students. Using peppers as the crop of focus, the “Building Better Peppers” project began in 2010 to improve fruit quality traits by using conventional plant breeding methods. Using single seed descent method of selection, several introgression lines (ILs) of cultivated tomato relative, Solanum pennellii, could be used in drought-related cowpea breeding programs.

Evaluation of Drought Tolerance in Cowpea at Seedling Stage

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Cowpea [Vigna unguiculata (L.) Walp.] is one the most important cultivated legumes worldwide. Cowpea cultivation is predominantly found in Africa, and other areas such as Asia, Oceania, and Central and South America are also suitable for cowpea growing. Drought has been proved to unfavorably limit cowpea production, which could lead to a lesser interest from farmers in growing cowpea despite of its cultivation being profitable. Providing growers with more drought-tolerant cowpea cultivars could help address this issue. Therefore, the objective of this study was to evaluate cowpea drought tolerance at seedling stage. A total of 30 cowpea genotypes were evaluated for drought tolerance in this study. Cowpea genotypes were planted within each box as one replicate. Plants were regularly watered until the first trifoliate was fully expanded. Drought stress was imposed until most of the genotypes were completely dead. Data were analyzed using ANOVA in JMP® Genomics 7. Data on soil moisture content, chlorophyll content in unifoliate and trifoliate leaves, number of wilted, chlorotic, lodged and dead plants, overall plant greenness, and recovery rate after rewatering were collected weekly. Leaf width and length were measured prior to drought stressing the plants. Stem diameter was recorded when plants first showed wilting signs. Results revealed that 1) a large variation in drought tolerance was found among the genotypes, 2) PI293469, PI293568, and PI349674 were highly drought-resistant based on overall plant greenness, chlorophyll content, number of wilted, chlorotic, lodged and dead plants, overall plant greenness, and recovery rate (P < 0.0002), and 3) a high correlation was found between overall plant greenness and percentage of dead plants (r = 0.74). The findings could be used in drought-related cowpea breeding programs.

Germination-trait Selection for Drought Tolerance In Solanum pennellii Introgression Lines

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Drought is one of the most important abiotic stresses to affect crop growth and development of tomato. The sensitive stages to drought are the seed germination and seedling growth. The development of drought-tolerant cultivars during germination is one important strategy to overcome this problem. An important resource to improve tomato tolerance to drought is the collection of introgression lines (ILs) of cultivated S. lycopersicum that contain different chromosomal segments derived from the wild tomato relative, Solanum pennellii. Thus, the objective was to evaluate and select tomato ILs, based on water deficit tolerance during germination. Forty-nine genotypes were evaluated: 46 S. pennellii ILs, M82 (sensitive recurrent parent), Santa Clara (sensitive variety), and accession LA 716 (S. pennellii) tolerant genotypes. The experimental design was completely randomized with four replications. The stress level (~0.3 Mpa) has been obtained by adding PEG-6000 to distilled water. After the distribution of the seeds were in gerbox plastic boxes on two sheets of GermiTest paper which were brought to growth chamber at 20 to 30 °C, 12 hours light. The evaluated characteristics were: seedling length (shoot, root and total), % first count germination at day 5, % total germination at day 14 (TG), germination index,
mean germination time and germination rate. Selection index (SI) was calculated based on by the sum of the values obtained for each trait multiplied by the trait weight. The trait weight used was obtained through its correlation with TG. Different degrees of tolerance were identified by gradient. The intensity of selection used for genotype selection was 10%. Accession LA 716 presented the highest value of SI (0.801) of a genotype IL 7-5-5 the lowest value (0.086). Accession LA 716 was the most tolerant among the evaluated genotypes. Therefore, the introgression lines IL4-2, IL4-4, IL9-1, IL3-5; IL4-1 were selected as the most drought tolerant.

Creating a Unique Tomato Plant by Grafting Multiple Scions onto One Rootstock

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Vegetable grafting is an innovative tool for soil-borne disease management and plant growth improvement. This study proposed that grafting could also be used to create a more colorful and unique tomato plant for home gardeners by using selected rootstock and scion cultivars. The objective was to determine a methodology for successfully grafting three different tomato scion cultivars onto one rootstock in order to generate one plant that produces fruit from three cultivars. Three experiments were conducted to explore different grafting methods including tongue approach, splice, and cleft grafting. Six commercial tomato cultivars yielding small-sized fruit were trialed in different grafting combinations as either scion or rootstock. In addition, a commercial tomato rootstock was used. Tomato plants at various growth stages (before flowering) were grafted. Grafted plants were placed in a healing chamber for 7–8 days and then grown in the greenhouse for 3–5 days to determine the graft survival. The use of tongue approach method in grafting multiple scions onto one rootstock in younger plants was unsuccessful. Larger tomato plants could be successfully grafted using the splice or cleft method. It was found that multiple scions could be grafted onto one plant by making use of lateral branches. Both simultaneous and staged grafting demonstrated successful healing. Pinching may induce more lateral branches suitable for grafting. Successional grafting will be further implemented to examine different scion-rootstock combinations. The impacts of multiple scions on grafted plant growth and fruit development in field conditions will be assessed in future studies.

Phenomics of Cowpea at Seedling Stage under Salt Stress

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Cowpea is an economically important legume. Salinity adversely impacts cowpea growth and development. Understanding phenomics for salt tolerance in cowpea will assist in developing better phenotypes for advancing cowpea breeding for salt tolerance. However, studies on the phenomics under salt stress in cowpea remain limited. The objective of this study was to investigate the phenomics of cowpea at seedling stage under salt stress. Salt concentration consisted of 0, 50, 100, 150, 200, and 250 mM. Six cowpea genotypes, P1528468 (highly salt-tolerant genotype), P1255774 (highly salt-susceptible one), P1262179 (moderately salt-tolerant), P1582573 (moderately salt-susceptible), P1582402 (moderately salt-susceptible), and P1582697 (moderately salt-susceptible) were used in this study. The experiment design was split-plot with NaCl concentration as whole plot portion and genotype as split-plot portion with three replicates. Salt treatment was applied for 20 days. Phenomes included net photosynthesis activity, stomatal conductance, intracellular CO$_2$ concentration, transpiration rate, instantaneous water-use efficiency, intracellular CO$_2$ concentration/ambient CO$_2$ ratio, chlorophyll content, leaf injury, plant height, and leaf and stem biomass. ANOVA was conducted using JMP Genomics 7. Results revealed that net photosynthesis, stomatal conductance, transpiration rate per unit area, and instantaneous water-use efficiency were rapidly affected by salt stress even at low NaCl concentration. Significant effect of NaCl concentration × cowpea genotype was identified (P < 0.05). Instantaneous water-use efficiency was significantly associated with salt-tolerance. Significant decrease in plant height and shoot biomass was observed. These results suggested that phenomes played a critical role in salt stress in cowpea. The findings will contribute toward establishing a high throughput phenomics platform for salt tolerance in cowpea, which is critical in modern plant breeding.

Application of Genomic Selection on Anthracnose in Texas A&M’s Watermelon Breeding Program

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Genomic selection (GS) is a form of marker-assisted breeding, which uses high-density markers throughout the organism’s genome to calculate genomic estimated breeding values (GEBV). It is used to predict the phenotype by genotyping individual. The GS uses a training population (TP) to develop the parameters of the statistical model that calculates the GEBV. To assess the accuracy of the GEBV a validation populations (VP) are created. This makes GS a promising resource for plant breeders, which would allow for an increase in annual genetic gains and a decrease in phenotyping costs. Unfortunately, it has only been widely used in animal and agronomic crops. To identify the potential of GS in vegetable crops, we propose to use genomic selection in watermelons. In our study the TP will be composed of 106 germlines that will be genotyped and screened for anthracnose resistance. To assess the accuracy of the GEBV our VP will consist of 500 individuals from 10 F$_2$ populations of crosses from the TP. If we are able to obtain a relatively high GEBV accuracy for anthracnose resistance, we will be able to
develop cultivars with anthracnose resistance in a short period of time (within 5 years).

Phytotoxicity of Mustard Meal Applications on Weeds and Squash (Cucurbita pepo L.) Establishment

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Mustard seed meal (MSM) can injury or kill germinating and developing plants, therefore, it is considered phytotoxic (toxic to plants). Weed control is a very costly and time-consuming aspect of crop production; this is especially true under certified organic production systems. MSM has a potential use as pre-emergent and preplant-incorporated organic herbicide for controlling germinating and emerging weed seedlings: unfortunately, MSM may also adversely impact seedling survival of certain direct-seeded vegetable crops. Field research was conducted in southeast Oklahoma (Lane, OK) to determine the phytotoxic impact of MSM on indigenous weeds and seedling establishment of yellow squash (Cucurbita pepo L.) var. ‘Crookneck’. The factorial experiment included 2 MSM incorporation levels (no incorporation and incorporation), 2 MSM application rates (2.25 and 4.5 mg/ha), 2 application patterns (banded and solid), 2 experimental control treatments (1 for each incorporation method) and four replications. The soil [Bernow fine sandy loam, 0 to 3% slope (fine-loamy, siliceous, thermic Glossic Paleudalf)] was prepared for planting by plowing, fertilizing, and forming raised beds. MSM was applied to raised beds 3 m-long on 0.76 m-centers. The banded application produced a 10.2 cm-wide MSM-free area in the bed center where the crop would later be direct-seeded. The MSM was then either left on the surface or incorporated into the top 2.5–5.0 cm and then direct-seeded with watermelon. Plant stands and weed control ratings were collected during the experimental period. Twenty-eight days after planting (DAP), the entire plot was harvested and the fresh and dry plant weights determined. Although applications of MSM provided sufficient broadleaf, grass, and total weed control, the MSM severely reduced squash establishment. Further research should address banded applications of MSM with either established direct-seeded or transplanted cucurbits and other vegetable crops in the same manner as others have done with corn gluten meal.

Screening Potato Germplasm for Tolerance/Resistance to Zebra Chip Disease under Greenhouse Conditions

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Zebra Chip (ZC) disease caused by the bacteria Candidatus Liberibacter solanacearum (Lso), and vectored by the potato psyllid (Bactericera cockerelli Šulc) causes significant yield and quality losses in potatoes. The use of resistant (or tolerant) potato cultivars is being considered as an important part of an integrated approach to manage the disease. Our objective was to identify sources of tolerance/resistance to Lso that can be used to incorporate resistance into commercial varieties by screening diploid and tetraploid potato accessions. Artificial infestation with Lso positive psyllids was done in greenhouse controlled experiments isolated from natural insect presence. Tubers were chipped and evaluated for chip quality and ZC rating. Highly tolerant clones were identified in both tetraploid and diploid. The findings indicate that genetic tolerance to ZC is available in potatoes and could be used for future breeding work.

Spring and Fall Production of Brussels Sprouts under Rowcover in Virginia

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Small and medium-sized farmers use rowcover as low tunnel to protect specialty crops against cold temperature and to extend the growing season. It increases temperature, which protects against light freezes and promotes vegetative growth leading to an increase in productivity. Rowcovers are used mainly in the spring, but can also be used in late summer-fall to enhance productivity of cool season crops. In addition, rowcover can protect against insects, which makes it an additional tool for organic production. In this study, we demonstrated that rowcover (1 oz/yd2) increases growth (leaf area and stem length) and production (sprouts number and yield) of spring and fall Brussels sprouts grown under low tunnels in comparison to open field condition in Virginia. The number of sprouts increased by 29%, both in spring and fall. Similarly, yield under the tunnel increased by 45% and 66% in spring and fall, respectively. The main micro-environmental differences between low tunnel and open field were maximum temperature, wind and solar radiation that reduced the estimated evapotranspiration. Rowcover also reduced the insect feeding injury from foliar worms. The feeding injury index was determined based on a 0–4 scale. The average feeding injury index in the open field and under the tunnel was 2.4 and 1.3, respectively. The two main insects found feeding in Brussels sprouts were Salt Marsh Caterpillar and Imported Cabbage Worm. In conclusion, low tunnels covered with spun-bonded fabric improve micro-climatic conditions, especially evapotranspiration, which favor vegetative growth and increase crop productivity. Rowcover also protect against insect pests and reduce feeding injury, which may result in less or no pesticide applications.
Sugarcane Bagasse Biochar as an Amendment to a Soilless Growing Media for Squash Seedling Production

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In 2016, Louisiana sugarcane farmers harvested 11.7 million Mg millable sugarcane from 163,000 ha, producing 1.47 million Mg of raw sugar and an estimated 3.5 million Mg of bagasse. Bagasse is the fibrous plant by-product remaining after removing the sucrose, water, and other extraneous material impurities from the sugarcane brought to the mill. Even though Louisiana sugar mills use 80 to 90% of the bagasse for fuel production, another 350,000 to 700,000 Mg of bagasse accumulates each year. The conversion of the excess bagasse into biochar is an excellent option with numerous uses. Research was conducted to determine the impact of sugarcane biochar as an amendment to soilless planting media for the production of squash seedlings. Two biochars were combined by volume with a commercial certified organic soilless growing media into five combinations (0%:100%, 25%:75%, 50%:50%, 75%:25%, and 100%:0%, biochars and growing media, respectively). ‘Enterprise’ squash (Cucurbita pepo L.) was planted in each of the five different planting mixtures. The higher heating value (HHV), lower heating value (LHV), and fixed carbon (FixC) were greater for the standard bagasse biochar (SBB), therefore, making it more valuable as a potential fuel source than the pneumatic bagasse biochar (PBB). The physical analysis of the soilless media combinations revealed low bulk densities (0.11–0.14 g/cm3) and high water holding capacities (80 to 87%). As an amendment to the soilless greenhouse growing media, the biochars (SBB and PBB) performed well, especially at the 25 and 50% levels. The 100% biochar growing media are not recommended because there was often a decrease in plant material. These results indicate that the volume of a standard soilless greenhouse growing media can be successfully extended by adding 25 to 50% sugarcane biochar without a reduction in squash seedling production. Future research should investigate the impact of additional plant species, as well as different biochar sources on seedling production.

Effect of Chemical and Mechanical Potato Vine Desiccation on Tuber Yield, Skin Removal, and Postharvest Quality

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Vine killing induces a uniform development of skin set and reduction of skinning injury, improved storage by limiting water loss and avoidance of disease. Chemical vine desiccation consists of herbicide application to the above ground biomass, whereas flail mowing and rolling are mechanical methods. The study objective was to evaluate the effect of chemical and mechanical vine desiccation on tuber yield, internal quality, degree of skinning, peel resistance, and postharvest quality maintenance of ‘Red LaSoda’. A field experiment was conducted during spring of 2017 in Hastings, FL, with randomized complete-block design and four replications. Vine killing treatments were non-treated mechanical (mowing), glufosinate [0.43 kg·ha−1 applied ingredient (a.i.)], carfentrazone (0.10 kg·ha−1 a.i.), diquat (0.56 kg·ha−1 a.i.), and paraquat applied 14 days before harvest (DBH). There was a significant vine desiccation type effect on tuber total and marketable yield. However, yield of non-treated plants was not significantly different from treated plants. Skinning severity at harvest was significantly affected by vine desiccation type. The non-treated and carfentrazone had the highest skin severity at harvest. There was no significant effect of vine desiccation type on internal quality, specific gravity, peel resistance to skinning, and fresh weight loss during storage. Peel resistance to skinning significantly increased from 14 DBH (0.3 N·m) to harvest day (0.6 N·m). Similarly, cumulative weight loss significantly increased by 1.09% of initial fresh weight from 7 to 21 days of storage. Vine desiccation type does not improve tuber skin set and postharvest quality maintenance.

Supplemental Daily Light Integrals Influence Carotenoid Concentrations in Hydroponically Grown ‘Genovese’ Pesto Basil

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Plants have the ability to respond to a wide range of intensities and narrowband wavelengths from the solar spectrum. While many studies have shown that light emitting diode (LED) supplementation is useful for high-value specialty crop production, research is needed to determine the value and efficacy of LEDs in comparison to traditional lighting systems, with emphasis placed on determining the impact of spectral distribution and daily light integral (DLI) on secondary metabolism. The objective of this study was to establish the effects of progressive DLI on the production of carotenoid and chlorophyll pigments in hydroponic basil (Ocimum basilicum var. ‘Genovese’) using LED and high-pressure sodium (HPS) lighting sources. A total of nine lighting treatments were used: one non-supplemented natural light control, two HPS treatments with DLIs as 12 h and 24 h, and six 20B/80R LED treatments with progressive DLIs as 3 h, 6 h, 9 h, 12 h, 18 h, and 24 h. Each supplemental lighting treatment provided 100 μmol·m−2·s−1. The DLI of the natural light control averaged 9.9 mol·m−2·d−1 during the growth period (ranging from 4–20 mol·m−2·d−1). Relative humidity averaged 50%, with day/night temperatures averaging 29.4 °C/23.8 °C, respectively. Basil plants were harvested 45 d after seeding, and leaf tissue pigments were analyzed using HPLC (Agilent 1200 Series). Concentrations of lutein, β-carotene, chlorophyll a, chlorophyll b, antheraxanthin and zeaxanthin varied among DLI supplements and natural light controls. Xanthophyll cycle
flux ratios were significantly impacted by DLI supplement and lighting type. Further research should be conducted to establish the relationship between specific DLI supplements and the biosynthesis of nutritionally important carotenoids. Because LEDs have the potential to improve antioxidant concentrations in many high-value specialty crops, various herb varieties should also be evaluated to determine the biochemical and physiological impacts of LED supplemental lighting.

Sweetpotato Variety Evaluation in Georgia

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Sweetpotato (\textit{Ipomea batatas}) acreage has grown in Georgia recently, with approximately 5000 acres planted in 2017. The variety Covington is dominant, accounting for more than 80\% of acreage. ‘Covington’ offers quality and production attributes that producers find attractive; however, recent growers have been trialing other varieties in efforts to increase yields as well as reduce days to harvest. Slips of 11 varieties were planted in two locations (Reidsville and Tifton) in Georgia on 15 and 16 June 2017. Slips were planted on rows spaced on 36-inch centers with 12-inch in-row spacing. Plots contained 50 plants each with four replicates of each variety. Sweetpotatoes were harvested approximately 116 d after planting. Sweetpotatoes were graded into US No. 1, petite, jumbo and culls. ‘Bayou Belle’ was the highest yielding variety in the Tifton, GA, trial, though total yields were not significantly different than two other varieties. ‘Covington’, was one of the lowest yielding varieties and not significantly different from the lowest yielding selection ‘NC04-531 NC State’. The top yielding variety in the Reidsville, GA, location was Orleans; however, that variety was not significantly different from several other varieties. Nonetheless, ‘Bayou Belle’, and ‘Orleans’ were two of the top three yielding varieties in both locations. In Reidsville, GA, ‘Covington’ was also one of the lower yielding varieties. The distribution of US No. 1 and US Petite sweetpotatoes was similar in the Reidsville, GA, location. In the Tifton, GA, location, US No. 1 yields were significantly greater than US Petite yields. Quality overall was commercially acceptable. Red-skinned varieties appeared more attractive at digging, but after harvest did show damage more than lighter, brown-skinned varieties.

Watermelon Germplasm Evaluation for Yield and Its Components in South Texas

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In 2016, Texas was the United States’ leader in watermelon [\textit{Citrullus lanatus} (Thunb.) Matsum. and Nakai] acreage planted 28,000 (USDA NASS, 2016). The estimated production value of watermelons in Texas was $72.5 million, which was the second largest of all vegetable crops grown in the state. Unfortunately, it was the second to last in yield per acre (36,405 kg·ha\textsuperscript{-1}) of the top 10 major watermelon producing states. The objectives of the study were to evaluate germplasm, to understand genotype-by-environment interaction, and to identify important yield components for watermelon breeding program. We evaluated 18 watermelon germplasms and looked at yield, soluble solids, rind thickness, vine length, fruit length, circumference, and weight at two locations, Uvalde and Weslaco, TX. The data collected was analyzed for genotype by environment (GGE), Pearson correlation coefficient, and path coefficient analysis, using R-software. We constructed a genotype by environment (GGE) biplot for yield, and genotype by trait biplot. The GGE biplot showed that there was interaction between genotypes and locations. TAM22 performed well at Uvalde, whereas UGA7 performed well at Weslaco, TX. The genotype by trait biplot showed that TAM35 was a better germplasm as it contained better values for yield, soluble solids, fruit length, and weight. We also conducted a path analysis, with yield, soluble solids, vine length, fruit weight, length, and circumference being the dependent factors. We found positive direct effects from fruit weight, circumference, and vine length on yield, which indicated that increasing fruit weight, circumference, and vine length would increase yield. The positive direct effects of fruit weight and circumference were reduced by the negative indirect effects of brix, fruit length, rind thickness, and vine length. The results inferred that increasing fruit weight and circumference would increase yield, whereas vine length would increase yield, but up to a certain length. The results showed that soluble solids, fruit length, and rind thickness would decrease yield as they had negative direct effects. We can conclude that fruit weight and circumference are important yield components and positive selection on these yield components would indirectly selection for high yield.

Grape Tomato Production and Consumer Perceptions

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Grape tomatoes have become popular additions to the produce offerings at supermarkets across the country. These tomatoes are smaller in size than cherry tomatoes making them desirable for salads and snacking. Several varieties are now available from many seed sources. Sixteen varieties were evaluated at the Beaumont Horticultural Unit in Beaumont, MS, in the summers of 2002 and 2003. Samples of 11 varieties were sent to
the Garrison Sensory Evaluation Laboratory for evaluation by panelists in 2003. An expert panel was conducted evaluating the reactions of respondents. All panelists were instructed to taste and evaluate the attributes of appearance, shape, size, color, gloss-shininess, translucency, stem, stem appearance, aroma, descriptor terms of aroma, general tomato aroma, hand/texture/firmness, mouth/bite/skin penetration, skin chewability, firmness of flesh, mealininess, juiciness, mushiness, internal pressure in mouth, seed/seed size, flavor, sweetness, sourness, saltiness, umami, overripe flavor, and general tomato flavor. Based on the information gathered through the sensory evaluation panel, ‘Mini Charm’ was the most preferred grape tomato in this study. ‘Mini Charm’ ranked first in 11 of the 20 attributes evaluated. The least preferred ‘St. Nick’.

—Postharvest—

Evaluation of Red Drupelet Reversion in Blackberries using High-throughput Digital Image Analysis

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Red drupelet reversion is a postharvest disorder that affects consumer perception of fresh-market blackberries. Evaluating fruit for reversion is time consuming, labor intensive, and subject to bias. Both objective and subjective methods were used to quantify red drupelet reversion in twelve blackberry genotypes from the University of Arkansas blackberry breeding program. Two replications of ripe, fully black fruit were harvested on two dates per genotype and placed in \(~\text{170-g} \text{ vented clamshells.}\)

Digital images were taken of the blackberries in the clamshells prior to cold storage (~4 °C) for seven days (original). Additional images of fruit were taken immediately after removal from cold storage (cold) and after berries reached room temperature (RT). Images were analyzed using color thresholds (hue, saturation, and brightness) in ImageJ to generate values for total berry area and red drupelet area from which percent reversion was calculated for each image. Berries were returned to room temperature after cold storage and visually evaluated using two methods, berry count and drupelet count, from which percent reverted berries and percent reverted drupelets were calculated. The berry count method involved counting the total number of berries per clamshell and counting number of berries having three or more red drupelets. For drupelet count method, a subset of five berries per clamshell were randomly selected and total number of drupelets along with number of red drupelets were counted. Significant differences in reversion existed among genotypes using both visual methods (berry count and drupelet count) and all three image-based measurements (original, cold, and RT). Significant main effects for genotype, harvest date (nested within genotype), and temperature treatment were found in all three ImageJ analyses \((P < 0.01)\) and no significant interaction was found between genotype and temperature treatment \((P > 0.05)\). Estimates of percent reverted berries and percent reverted drupelets were positively correlated with each other \((r = 0.96)\) as well as with all three image analysis temperature treatments (original, cold, and RT), ranging from \(r = 0.76\) to \(r = 0.88\). The percentage of reverted berries and the percentage of reverted drupelets were more highly correlated \((r = 0.88\) and \(r = 0.87,\) respectively) with images taken before cold storage than with images taken after cold storage. This suggests reversion began to take place during storage in a cooler in the field before original images were taken. Our study supports the ability of ImageJ to quantify red drupelet reversion, potentially allowing more genotypes to be analyzed without bias within a reasonable timeframe compared to subjective methods.

Impact of Sweetness and Sourness on Sensory of Fresh-market Blackberries

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As new fresh-market blackberry cultivars are developed in breeding programs, marketability to consumers is an important factor that drives their release. Since sweetness and sourness are key attributes important in marketability of fruit, the objective of this study was to investigate how these attributes impact consumer acceptability of blackberries. Three Arkansas-grown fresh-market blackberry genotypes (two cultivars and one selection) were hand-harvested at the shiny-black stage of ripeness and evaluated for consumer sensory attributes at the University of Arkansas Food Science Department, Fayetteville. ‘Natchez’ and ‘Ouachita’ were harvested from a commercial grower in Fayetteville, AR and A-2418 was harvested from the University of Arkansas Fruit Research Station, Clarksville, AR. The blackberries had a commercially acceptable range for soluble solids (8.2 to 11.9%), pH (2.8–3.2), titratable acidity (1.1 to 1.3%), and soluble solids to titratable acidity ratio (6.2–10.9). Soluble solids/titratable acidity ratio is used to determine the balance of perceived sweetness or sourness. The goal was to harvest blackberries with three distinct ratios (low, medium, and high), thus ‘Ouachita’ had a ratio of 10.9, ‘Natchez’ had a ratio of 8.9, and A-2418 had a ratio of 6.3. A consumer sensory panel (\(n = 80\)) evaluated the blackberries and ranked them in order of overall liking from most to least, and then the consumers tasted and ranked four sugar/acid solutions with soluble solids to titratable acidity ratios of 16%, 11%, 9%, and 6% (one high, two medium, and one low). ‘Natchez’ was significantly liked over the other genotypes as it was ranked first for 53% of the consumers as compared to 26% for A-2418 and 21% for ‘Ouachita’. Consumers liked the 16% sugar/acid solution the most followed by the 11% solution, the 9% solution, and then the 6% solution, 50%, 28%, 20% and 2%, respectively. These sensory findings showed that half of the consumers liked the highest sugar/acid ratio solution (16%), but when consumers tasted the blackberries over half of the consumers liked ‘Natchez’.
Effects of High Tunnel Production on Postharvest Marketability of Arkansas Table Grapes

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The marketability of table grapes (Vitis sp.) is dependent on the capacity of the fruit to maintain quality before reaching the consumer. Table grapes grown in the southern region of the United States are an extremely high input crop because of pest pressures in a humid climate requiring high fungicide and insecticide inputs. The economic and environmental sustainability of grape production could be improved in the southern region by producing grapes in protected agriculture systems such as high tunnels (passively heated structures that physically protect crops). Postharvest marketability of Arkansas table grapes from two production systems (high tunnel and traditional) was evaluated. Three University of Arkansas cultivars (Gratitude, Jupiter, and Mars) were harvested from a traditional vineyard at the Fruit Research Station, Clarksville, AR and from a high tunnel vineyard at the Arkansas Agricultural Research and Extension Center, Experiment Station, Fayetteville. The fruit was hand-harvested into 0.9 kg vented clamshells in July–Aug. 2017. Two clusters per clamshell were evaluated in triplicate for physicochemical and marketability attributes. Physicochemical attributes (berry weights, berry firmness, and composition) were evaluated at harvest (day 0) and marketability attributes in a clamshell [weight loss, decay, and berry drop (shatter)] were evaluated during storage (0, 7, 14, and 21 days) at 2 °C. At harvest, the cluster weights ranged from 128.9–433.7 g and had a soluble solids of 12.0 to 17.3%, pH of 3.1–3.7, titratable acidity of 0.4 to 0.6%, and firmness of 2.5–4.4 N. Weight loss during storage was less when grown in a high tunnel (1.3%) than when grown in a traditional vineyard (1.7%). There was a significant interaction between production system x storage for decay and genotype x production system for shatter. The fruit grown in the high tunnel had less decay than traditionally grown fruit at each storage time. After 21 days, grapes from the high tunnel had 1.3% decay as compared to fruit grown in a traditional vineyard (8.0%). Mars’ and ‘Jupiter’ had more shatter when grown in the traditional vineyard (6.0%) and (6.3%) as compared to high tunnel (0.0%) and (0.6%), respectively. ‘Mars’ and ‘Jupiter’ grown in the high tunnel had the least shatter, whereas ‘Gratitude’ was not impacted by production system and had less than 2.5% shatter. Storage did not impact shatter of the table grapes, but increased decay and weight loss. For these table grape cultivars, postharvest marketability was improved by growing grapes in high tunnels.

Flavor Volatiles in Southern Highbush and Rabbiteye Blueberry Varieties

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The commercial blueberry in Georgia and in the southeastern United States is composed of two major types of blueberry: southern highbush (Vaccinium corymbosum L.) and rabbiteye (V. virgatum Aiton). The fruit quality of these two types is often a subject of discussion in the blueberry industry, ranging from textural traits to flavor characteristics. Currently, there is limited information comparing the flavor volatile compound profiles of southern highbush and rabbiteye blueberry varieties. The objective of this study was to profile and to quantify the flavor volatile compounds of varieties currently grown in Georgia. From April to July 2016, fresh fruit was collected from commercial blueberry packers for two southern highbush varieties: ‘Emerald’ and ‘Camellia’; and for two rabbiteye varieties: ‘Alapaha’ and ‘Premier’. Fruit were frozen and stored at −15 °C until processing. Fruit were processed for flavor profiles approximately two weeks (11–16 days) after the respective consumer taste panel in which the variety fruit samples were tested. Fruit were thawed at 20 °C and samples were prepared for flavor volatiles headspace solid phase microextraction (HS-SPME) using a GC-MS. Varieties were examined for 11 compounds commonly found in Vaccinium spp., five of which relate to blueberry flavor and aroma. Out of the six flavor volatiles commonly identified in Vaccinium spp., three were identified in all four varieties examined (limonene, nerol, and α-terpineol). Out of the five flavor volatiles known to be associated with blueberry flavor and aroma by trained sensory taste panelists, two were identified across the four varieties (linalool and trans-2-hexenal). A third flavor volatile (geraniol) was identified in southern highbush, but was not detected in rabbiteye. The two types were compared for overall type differences for volatiles present in all varieties tested. For all five compounds examined, rabbiteyes were significantly higher than southern highbush, ranging from 40% higher (linalool) to over three times higher (trans-2-hexenal). These initial results suggest that rabbiteyes may be perceived as having more blueberry flavor than southern highbush. Results from this study will be incorporated into a larger variety data set which will be examined for relationships to consumer overall liking and acceptability of blueberry flavor for southern highbush and rabbiteye varieties.

Black Raspberry in North Carolina: Shelf Life and Composition

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Black raspberry (R. occidentalis) is neither blackberry nor red raspberry. Black raspberry fruit tend to be rounded and have a whitish appearance on the red-black drupelets. The fruit has been used successfully to treat esophageal and some oral cancers. While most of the fruit are used for processing, there is interest in using black raspberry for fresh market. Two North Carolina selections (NC348 and NC349) were compared to the cultivars Jewel and MacBlack to determine shelf life, fruit quality, and composition. Weight loss was 2% and 30% of berries were soft after 7 days at 4 °C, but not significantly different among selections. Soluble solids content was 11% and did not change with storage. Titratable acidity was 0.8% to 1% citric acid for days 0 and 7. Total organic acids generally decreased with storage. Carotenoid esters (18 µg/100 g dry weight) dominated the carotenoid HPLC profile. Of black raspberry and beta carotene and lutein were also present at 2.1 and 3.2 µg/100 g dwt. Sugars consisted of a trace of sucrose, 52% fructose, and 45% glucose and did not differ among selections. Jewel had the highest total anthocyanin content (288 mg/g dry weight); NC348 and NC349 were highest in cyanidin-3-xylloside (38–42 mg/g dwt) and lowest in cyanidin-3-rutinoside (41–47 mg/g dwt). This multi-year study indicates that improving fruit firmness may be the best approach to increasing fresh market shelf life and that fruit composition does not change dramatically after storage.

Impact of Flesh-type on Ripeness Attributes of Peaches and Nectarines during Postharvest Storage

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Peaches and nectarines (Prunus persica L.) are an important fruit for both fresh market and processing. The University of Arkansas Fruit Breeding Program focuses on peach and nectarine characteristics for fresh markets so ripeness attributes at harvest and during storage are important. Flesh type of fruit can impact ripeness attributes since melting flesh fruit soften rapidly and non-melting flesh fruit soften gradually. The ripeness attributes (chlorophyll, fruit weight, flesh firmness, and composition) of three melting flesh peaches and seven non-melting flesh nectarines were evaluated at harvest (day 0) and after storage at 2 °C for 7 and 14 days. The fruit was hand harvested in 2017 from the University of Arkansas Fruit Research Station in Clarksville at tree ripeness (fruit ripened on the tree) and commercial ripeness (fruit picked to ripen during storage). The chlorophyll A content of the fruit skin was measured using a Delta Absorbance Meter to indicate fruit ripeness. Tree-ripened fruit was harvested at a chlorophyll below 0.25, whereas commercially-ripened fruit was harvested at 0.5–1.0. After fruit was harvested, fruit weight and firmness were evaluated and then the fruit was frozen for composition analysis. The attributes of the commercially-ripened fruit were evaluated again after storage. At harvest, tree-ripened fruit had chlorophyll content of 0.12, fruit weight of 204–208 g, soluble solids of 9.90 to 9.93%, pH of 3.72–4.60, titratable acidity of 0.33–0.64%, and firmness of 7.96–13.03 N, whereas commercially-ripened fruit had chlorophyll content of 0.43–0.69, fruit weight of 174–193 g, soluble solids of 8.85 to 9.77%, pH of 3.52–4.44, titratable acidity of 0.37 to 0.81%, and firmness of 21.64–24.46 N. At harvest, both flesh types within commercially- or tree-ripened fruit had similar weights, soluble solids, and firmness, but regardless of flesh types, tree-ripened fruit had lower chlorophyll and firmness than commercially-ripened fruit. For both tree- and commercially-ripened flesh types, non-melting flesh fruit had higher titratable acidity and lower pH than melting flesh fruit. During storage of commercially-ripe fruit, non-melting flesh fruit had higher chlorophyll, firmness, and titratable acidity than melting flesh fruit. Chlorophyll and fruit weight of non-melting flesh types decreased and soluble solids increased during storage, but titratable acidity of both flesh types remained the same. Firmness of commercially-ripened, non-melting fruit increased at day 7, but decreased after day 14, while firmness of melting flesh fruit decreased during storage. For these peach and nectarine genotypes evaluated, flesh type impacted the ripeness attributes at harvest and during storage.

Postharvest Marketability of Arkansas Fresh-market Blackberries Harvested at 7:00 AM and 12:00 PM

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Increased postharvest storage performance in fresh-market fruits is extremely important to fruit breeders, growers, and consumers. In blackberries (Rubus subgenus Rubus) postharvest marketability relies on the capacity of the berries to maintain firmness and resist leakage, decay, and development of red drupelets (reversion) before reaching the consumer. Four cultivars (Natchez, Osage, Ouachita, and Prime-Ark® Traveler) and five advanced breeding selections were harvested from the University of Arkansas Fruit Research Station, Clarksville, AR at 7:00 AM and 12:00 PM at the shiny-black stage of ripeness. Berries were evaluated at harvest (day 0) and after 7 and 14 days at 2 °C. After harvest, berries were randomized and placed in 125 g vented clamshells in duplicate for both physicochemical and marketability analysis (firmness, weight loss, leakage, decay, and red drupelet reversion). At harvest (day 0) the berries among genotypes had soluble solids of 7.3 to 11.0%, pH of 2.5–3.5, and titratable acidity of 0.7 to 1.3%. Leakage and decay were not significantly different between harvest times for stored berries. Averaged for genotypes, berry leakage after 7 and 14 days was 8.4% and 21.1% and decay was 22.1% and 38.9%, respectively. However, significant differences among genotypes were found. During postharvest storage, Natchez had the highest incidence of leakage (18.9%) whereas A-2453 had the least leakage (5.6%). In addition, A-2444 had the most decay (30.0%) and Prime-
Ark® Traveler least (12.4%). In terms of time of day harvested, A-2444 was the least firm at the 7:00 AM harvest (4.4 N) and Prime-Ark® Traveler was the firmest (8.6 N). However, at the 12:00 PM harvest A-2453 was the firmest (11.0 N) and A-2526 was the least firm (4.2 N). There was a significant interaction for genotype × storage day × harvest time for red drupelet reversion. Except for ‘Natchez’ and Prime-Ark® Traveler, red drupelet reversion during storage was not significantly affected by harvest time. Postharvest marketability was mainly impacted by storage day and genotype rather than harvest time, although interactions between genotype and harvest time were found for berry weight loss and firmness. During postharvest storage Prime-Ark® Traveler had the least decay and was one of the firmest berries along with A-2453. A-2453 also had one of the lowest red drupelet reversions and the least leakage among the other genotypes indicating good storage performance. However, multiple years of data with varying environmental conditions would need to be further investigated.

— Cross-Commodity —

Nutrient Uptake and Growth Analysis of Actaea racemosa (L.) Grown under Shade in a Greenhouse

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Nutrient uptake of Black cohosh (Actaea racemosa L.) grown under 80% shade was analyzed in a greenhouse. Potted Test plants were treated with two nutrient treatments of Fusion 360 Gold Fertilizer: Single Feeding (SF, one time at the beginning) at 0%, 2%, 4%, 6%, 8% and 10% and Continuous Feeding (CF, weekly from the very beginning and through plant life cycle) at 0%, 2%, 4%, 6%, 8% and 10% concentrations. Plant growth data were collected when plants reached full growth. Nutrient uptake was analyzed at different stages of the plant life cycle. Samples were collected at the following stages for nutrient uptake analysis: Stage 1, pre-treatment: soil sample; Stage 2, pre-planting but after initial treatments: soil samples; Stage 3, right after see plant growth: soil samples; Stage 4, full growth: plant samples (leaf, stem, and root); and Stage 5, end of growth: soil samples. Total amount of Ca, Fe, K, Mg, Mn, and Zn were measured at different growth stages. The CF led to a significant decrease in the number of leaves, fresh stem height and diameter, canopy size, and dry weight of rhizomes. However, there was a significant increase in the number of stems as fertilizer concentration increased. Increased fertilizer concentration also led to an overall decrease in plant size, causing a dwarving effect. We observed no significant changes in plant growth with SF treatment, except for a decrease in stem length as the concentration of fertilizer increased. As Black cohosh plants matured, the average elements content gradually decreased in soil from its initial concentration. We observed that black cohosh plants absorbed calcium [Ca (26 to 40%)], potassium [K (36 to 48%)], magnesium [Mg (14 to 21%)], iron [Fe (2.9 to 4%)], and zinc [Zn (0.1 to 0.2%)]. Manganese was quickly absorbed at the initial plant growth, as indicated by the dramatic decrease amount in soil (Stages 1 and 2). Total elements amount decreased as plants matured. Accumulation of Ca and Mg were found primarily in leaf, K in stem, and Fe in rhizome. Trace amounts of Mn and Zn (< 2% of total element composition) were found in all plant parts and growth stages.

Allelopathic Impact of Sugarcane Field Residue and Root Leachates on Weed Seed Germination

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Chemical interactions between plants may result in the inhibition of plant growth and development. This chemical interaction is called allelopathy. One possible advantage of allelopathy is the potential of a crop to produce chemical compounds that will inhibit weed germination and growth. The objective of this research was to determine the allelopathic impact of sugarcane (Saccharum officinarum) field residue and root extracts on seed germination of three weed species. Red morning glory (Ipomoea coccinea L.), redroot pigweed (Amaranthus retroflexus L.), and spiny amaranthus (Amaranthus spinosus L.) seeds were treated with five extract concentrations (0, 12.5, 25, 50, and 100 g/L) from either sugarcane field residue or sugarcane root extracts. The field residue and roots were from sugarcane variety var. ‘HoCP 96-540’ plant cane. Germination generally decreased with increasing sugarcane field residue extract concentrations in the three weed species tested. At the highest residue concentration (100 g/L), red morning glory, redroot pigweed, and spiny amaranthus germination decreased by 29%, 17.5% and 80.5%, respectively. Germination generally decreased with increasing sugarcane root extract concentrations in red morning glory and redroot pigweed, but not with spiny amaranthus. The highest root concentration (100 g/L) decreased red morning glory and redroot pigweed germination by 19.5% and 18.5%, respectively. This research provides the first bioassay demonstrating that sugarcane root extracts have allelopathic activity, and specifically on red morning glory and redroot pigweed germination. Future research should investigate the allelopathic compounds present in the sugarcane field residue and roots, determine if the same allelopathic compounds are present and in the same concentration among other sugarcane varieties, and further examine which weed species may be vulnerable to the allelopathic compounds present in sugarcane roots.

Efficacy of Saponin Mitigation of E. coli under Nonsterile and Sterile Conditions

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Pathogenic serotypes of *Escherichia coli* (E. Coli) are among the leading causes of foodborne illness worldwide. Mitigation of this bacteria in crop irrigation water is limited due to system complexities and cost. Saponins are secondary metabolites found in many higher order plant species, and exhibit antibacterial effects by permeating cell membranes. In this study, different saponin concentrations (0, 25, 100, and 200 \( \mu g\cdot mL^{-1} \)) were evaluated for their effects on *E. coli* suppression under nonsterile and sterile conditions. All saponin treatments above 0 \( \mu g\cdot mL^{-1} \) suppressed *E. coli* populations. At a saponin concentration of 0 \( \mu g\cdot mL^{-1} \) different population trends were observed under nonsterile and sterile conditions. Under sterile conditions, *E. coli* populations declined in a typical bacterial life cycle. Under nonsterile conditions, *E. coli* populations made a resurgence after initial die back.

**The Effect of Shade Cloth Color on Greenhouse Cooling Efficiency**

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Four quonset cold frames located at the Ornamental Horticulture Research Center in Mobile, AL, were used to evaluate the cooling efficiency of black, white, and reflective (Aluminet®) knit shade cloth. Each cloth was rated at 50% light transmission. Structures were a positioned East to West. Each structure measured 5.5 m. in width, 8.75 m. in length and were 3 m. at the apex. Natural ventilation was provided with doors at each end wall with a surface area of 6.5 m² per door. Treatments were randomized weekly over four a four-week period. The following data were collected on 30-minute intervals: photosynthetic active radiation, temperature, and relative humidity. No differences were observed in noontime temperature between shade colors. The unshaded control remained above 36 °C for 50% more time than the shaded treatments. No differences were observed in the number of hours above 34 and 36 °C between shade treatments. Throughout the study, plant available light peaked at 1:00 PM. Measurements of PAR between the unshaded control and the shaded treatments were 57, 50, and 40% for black, reflective, and white, respectively. White shade cloth had 30% more PAR than black shade cloth and 17% more than reflective. Reflective provided 15.5% more PAR than black shade. Similar to the mean maximum PAR, the white shade provided 32% more DLI than the black shade. No advantages were observed in temperature reduction between shade cloths; however, white shade cloth provided more plant available light when compared to the black and reflective treatments. The white material appeared to be somewhat transparent and likely contributed to the increase PAR. The greenhouses used in this study would be considered a worst-case scenario in regards to ventilation efficiency. Different results may occur with more efficient structure types. In other studies, black shade cloth has been shown to be less efficient in temperature reduction when compared to reflective due to rations of absorbed heat back into the greenhouse. The double poly covering may have provided an insulation effect from any radiated heat from the black cloth.

**Creating a Reference Collection of Fall Pollinators Observed on Cucumber and Pepper Crops Grown with Companion Plants in Central Texas**

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It is well known that honey bees, as well as butterflies, provide the pollination services for many horticultural crops. However, there are numerous taxa of other insects that also may serve as pollinators. By knowing what insect species pollinates certain plants, a grower can begin to learn and understand the relationships among plants and their pollinators. Furthermore, a grower could potentially target certain insect species by using companion plantings of flowering plants to attract insects and enhance crop pollination. The goal of this project was to curate a fall reference collection of pollinators found in testing two combinations of annual and perennial companion plantings grown adjacent to vegetable crops for use in future research and education in central Texas. Insects from 28 taxa were curated. These research and learning activities were in part funded and conducted in facilities supported by Hatch Funds from the National Institute of Food and Agriculture (NIFA).

**Working Groups**

**Watermelon Research Group**

**Watermelon Variety Evaluation in Georgia**

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Watermelon is an important vegetable in Georgia with nearly 20,000 acres planted annually. Variety trials are important to determine suitability of new varieties for growers. In 2017 there were 27 varieties of seedless melons trialed in Georgia and three seeded selections representing nine seed companies. Transplants were planted into raised beds with black plastic mulch and drip irrigation. Plots contained ten plants with four pollenizers. There were three replicates of all varieties arranged in a randomized complete block design. Plants were grown according to University of Georgia Cooperative Extension recommendations. Melons were harvested three times and subsamples of each variety were tested for soluble solids, hollow heart, firmness, and hard seeds. The variety, Summer Breeze was the highest yielding entry in 2017; however, it was not significantly different from nine other varieties. The highest average fruit weight was 21.0 pounds in ‘SV3105’ and the lowest was 13.1 pounds in ‘Bejo 3038’. The variety with the highest percent of 45-count fruit was Secretariat with 66% of fruit in this size category. The earliest maturing
variety was Sweet Dawn, with 65% of fruit harvested in the first to harvests. Firmness was greatest in ‘KB10770.’ This variety was significantly firmer than all other varieties tested. Total soluble solids ranged from 10.1% to 11.8%. This information will help The University of Georgia Cooperative Extension Service make recommendations for watermelon growers in the state of Georgia.

Watermelon and Melon Production in Myanmar
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Myanmar is a country of approximately 54 million people in southeast Asia sharing borders with Thailand, Laos, China, India, and Bangladesh. Watermelon and muskmelon production is significant. Production is located primarily in the central dry zone near the cities of Mandalay and Monywa. Total watermelon exports to China have ranged from 440,000–600,000 tons annually in recent years. Watermelons are grown throughout the year, but most production for export is grown for harvest in winter and spring months. Watermelon production is intensive with most growers using plastic mulch for production. Drip and furrow irrigation are the most common methods of irrigating plants. Most export watermelons are diploid, although limited acreage of triploid melons exists. Female flowers are pollinated manually. Typically three flowers approximately 1.5 m from the crown of the plant are pollinated. Plants are pruned and thinned to one fruit shortly after pollination. Growers limit production to one fruit per plant in order to achieve the desired size (10 kg) for export. Major issues include labor costs, bacterial fruit blight, and powdery and downy mildews. Fruit blight is a significant problem, most likely resulting from contaminated seed. Crop losses routinely exceed 30% in some fields. Postharvest losses are also significant in transit. Opportunities to improve production include improving seed quality to reduce infection with bacterial fruit blight, increase production to two fruit per plant instead of one, and altering packaging for melons to reduce losses in transit.

Screening for Resistance to Anthracnose In the Watermelon Germplasm Collection Using Field, Greenhouse, and Growth Chamber Environments
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Anthracnose, caused by Colletotrichum orbiculare, has re-emerged as a major problem on watermelon (Citrullus lanatus). One gene for resistance, Ar-2-J, to watermelon anthracnose was identified in 1959 and is still durable today. In order to identify a higher level of resistance to anthracnose, we developed a test to separate the levels of resistance in the Citrullus germplasm collection. The goal of this study was to compare different environments for screening anthracnose resistance. The available watermelon germplasm collection of 1408 PI accessions was screened for resistance to anthracnose race 1 in field, greenhouse and growth chamber. Field screening used plants at flowering stage, whereas greenhouse and growth chamber screening used plants at seedling stage. Field and growth chamber experiments had two replications, and greenhouse study had four replications. Spore concentration of 10⁵ spores/ml was used across all the studies. The optimum environment was found to be greenhouse, as the top 10% of resistance identified in greenhouse included the best performing accessions from field and growth chamber. But the vise versa was not true, as field and growth chamber did not include resistant accessions identified in greenhouse.

Genetics of Resistance to Fusarium Wilt Races 1 and 2 in Watermelon
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The prevalent watermelon disease, Fusarium wilt, is caused by four different races (0, 1, 2, and 3) of the fungal pathogen Fusarium oxysporum f. sp. niveum (Fon). A QTL (Q1_fon1) that confers resistance to Fon race 1 in watermelon has been previously identified in multiple studies but suffers from low resolution (6.5 Mb) due to low marker density in the region. Here we present the results of a QTL-seq study of Fon race 1 resistance in Citrullus lanatus that has improved the resolution of Q1_fon1 to 1.5 Mb. Resequencing of the parents of the population and subsequent marker development further narrowed the region to 261 kb. In addition, we have identified a novel source of resistance to Fon race 1 from Citrullus amarus and compare it to a QTL for Fon race 2 resistance. KASP markers for these three Fon resistance QTL will be developed to aid in gene pyramiding into an elite C. lanatus background.

Late Spring Planting Reduces Fusarium Wilt Incidence in Seedless Watermelon
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Fusarium wilt of watermelon is a serious, widespread disease of watermelon throughout the southern United States. To investigate whether soil temperature affects disease development, three cultivars of seedless watermelon, Citation and Melody, susceptible to Fusarium wilt, and Fascination, resistant to Fusarium wilt race 1, were transplanted on three dates into naturally infested soil. The transplanting dates were: 21 Mar., 11 Apr., and 2 May in both 2015 and 2016 at Tifton, GA; and 18 Mar., 8 Apr., and 28 Apr. 2015, and 17 Mar, 7 Apr., and 26 Apr. 2016 in Charleston, SC. Incidence of Fusarium wilt was lower with late-season than with early and mid-season transplanting in all four experiments (P ≤ 0.01). Citation had a significantly higher incidence of Fusarium wilt than Fascination and Melody in three of the four experiments (P ≤ 0.01). For all cultivars, yields were greater in 2015 than in 2016 in both...
locations. In South Carolina, planting date did not affect weight and number of marketable fruit ≥ 4.5 kg apiece. In Georgia in 2016, weight and number of marketable fruit were greater with late transplanting than with early and mid-season transplanting. In both states, marketable yields and values for Fascination and Melody were higher than for Citation. In South Carolina, Fascination and Melody produced more mid-sized fruit (those weighing 6.2–9.7 kg apiece) and fewer fruit weighing < 4.5 kg than Citation did (P ≤ 0.03). Soil temperature averaged over the four-week period after transplanting was negatively correlated with Fusarium wilt incidence across all four experiments \( (r = -0.737, P = 0.006) \). Transplanting after mid-April and choosing a cultivar with partial resistance or tolerance can help to manage Fusarium wilt of watermelon in the southern United States.

**Metabolic and Molecular Regulation of Citrulline Biosynthesis in Watermelon**

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Watermelons are naturally rich in citrulline and hence are an ideal model to study biochemical, or molecular aspects of citrulline regulation. Partitioning of amino acids across the matured fruits of cultivar ‘Charleston Gray’ confirmed that citrulline alone accounts for 1/3 of total amino acids in the flesh and rind tissues. Unlike rind, the progressive accumulation of citrulline along with its precursor; ornithine and catabolic product; arginine during the fruit development was apparent in the flesh tissue. Changes in the gene expression profiles of N-acetylaminoethanethiol aminotransferase (AOD) and ornithine carbamoyltransferase (OTC) using quantitative real time-PCR aligned with citrulline accumulation in both flesh and rind tissues. Additionally, developmental up-regulation of biosynthetic carbamoyl phosphate synthase (CPS) gene during fruit maturation was observed in the rinds. Expression of catabolic arginosuccinate synthases (Cla019267, Cla002611, Cla002609) and arginosuccinate lyase (Cla022154) was suppressed during the fruit maturation in flesh and rind tissues. The steady expression profiles of OTC and CPS during fruit development in the flesh and their progressive induction in the rind; along with down-regulation of catabolic genes throughout the fruit development suggests precise regulation of genes involved in the synthesis and catabolism to maintain steady accumulation of citrulline in watermelons. Preliminary experiments suggested increasing accumulation of citrulline and induction of CPS and OTC genes in the tissues other than fruits during the drought stress. Although no significant correlation between rind thickness and citrulline accumulation was observed, the genotypic differences suggested differential partitioning of citrulline precursors and products in the flesh and rind tissues.

**Silver Nanoparticles Enhance Seed Germination, Growth, and Yield of Watermelon (Citrullus lanatus)**

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Watermelon is an important commodity of the U.S. produce industry, with significant production located in Florida, Texas, Georgia, and California. Part of its appeal to consumers is related to the high content in vitamins, minerals, and other health-promoting compounds. Growers across production regions have identified several critical production limitations and needs including: germination/stand establishment, stable yields, and retail/ nutritional/health quality attributes that attract consumers. To meet these critical needs and promote sustainable agriculture, we used onion extracts to synthesize silver nanoparticles (AgNPs) that can penetrate seed pores. These AgNPs can activate phytohormones to stimulate physiological growth. Biocompatible AgNPs were prepared by a dropwise reduction method and characterized using ultraviolet-visible spectroscopy and dynamic light scattering techniques. Formulated AgNPs were used as nanoprimer agents for seeds of two watermelon varieties (Riverside and Maxima) for 12 h. Dry unprimed seeds were used as control for this study. A germination experiment was conducted in an incubator at 30 °C for seven days. For the AgNP-treated seeds, the number of days required for 50% germination was reduced by 33% and 28% in ‘Maxima’ and ‘Riverside’, respectively, compared with untreated seeds. Hypocotyl length and fresh weight of germinated seedlings were significantly higher in treated seeds compared to the control. Seedlings grown in the greenhouse were field-transplanted at five locations in Texas: Edinburg, Premont, Pecos, Grapeland, and Snook. At 40 days after transplanting, vine length and thickness were higher in AgNP-treated watermelons for both varieties at all five locations. For ‘Riverside’ and ‘Maxima’, significant yield increases compared to control were observed at Snook and Grapeland. These observations indicate that AgNP priming of seed may contribute in reducing watermelon production costs associated with poor germination and stand establishment. We thank Texas Department of Agriculture (award # SC-1607-013) for supporting this work.

**2017 Triploid Watermelon Variety Evaluations in Southwest Indiana**

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Watermelon production in Indiana ranked sixth in harvested area in the United States. Variety selection is one of the key decisions in watermelon production. The objective of this study is to provide Indiana watermelon producers, as well as seed companies, with the updated information on performances of triploid and personal-sized triploid watermelon varieties grown in southwest Indiana. The variety trials included 37 standard size watermelons and 4 personal sized watermelons. In-row and between-row spacing for the standard-sized watermelon trials were 4 and 8 ft., respectively. Each experimental plot...
A grafted watermelon trial was conducted in 2015 on a disease challenged field at the University of Delaware Carvel Research Center. The rootstocks used for grafting were Harris Moran TZ148 interspecific Cucurbita hybrid and RKN 318 experimental root knot resistant rootstock. Treatments were ‘9651’ ungrafted Fusarium susceptible, ‘Fascination’ grafted, ‘Fascination’ ungrafted, ‘Fascination’ grafted, and ‘Tri x 313’ grafted. All grafted plants had significantly higher vigor than the ungrafted control 9651. The highest vigor plants were grafted onto the experimental root knot resistant rootstock, which was also significantly more vigorous than the ungrafted Fascination Fusarium tolerant control. Grafted ‘Fascination’, ‘Maxima’, and ‘Tri x 313’ were not significantly more vigorous than the ungrafted Fascination. Grafting onto Fusarium resistant rootstocks produced healthier plants. All grafted plants had significantly heavier fruit weights than non-grafted controls. In 2016, grafted Fascination using Harris Moran TZ148 interspecific Cucurbita hybrid rootstock planted at 78% of population of ungrafted Fascination yielded 22% higher. Fruits were heavier and there were significantly more fruits in the second and third harvests compared to ungrafted Fascination. Yields of grafted Fascination planted at the same population as ungrafted Fascination were not statistically different from ungrafted plots. In 2017, grafted Fascination and 7187 varieties onto interspecific Cucurbita Hybrid (HM TZ148) were planted into a disease challenged field using two nitrogen (N) rates, 80 and 120 lbs N/a and two plant populations, 9 and 6 plants per plot. There were no yield differences between populations; however, there was a N × Variety interaction. In 7187 highest yields were at 80 lb/a of N; in Fascination highest yields were with 120 lb/a of N.

How Sweet is Your Brix?

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Soluble Solid Content (SSC, measured as °Brix) is one of the most common traits measured in breeding and flesh quality evaluations of watermelon (Citrullus lanatus). Quantitative trait loci (QTL) have been identified for SSC in watermelon, but the loci are highly dependent on the population and environment used for mapping. The SSC is a desired trait due to its correlation with fruit sugar content. In this study we used a recombinant inbred line population, Klondike Black Seeded × New Hampshire Midget, to map QTL associated with fructose, glucose and sucrose content in watermelon fruit over two seasons. In both years QTL (R² = 10 – 28%) for all three traits were identified in an overlapping region (0.4 – 7.1 Mb) on chromosome 5 of the watermelon genome. Additional QTL for fructose and glucose content were identified on chromosome 8, but were not stable across years. QTL for SSC were also identified on chromosomes 5 and 8, but were not stable across years and did not differ between years.
not overlap with the locations of the QTL for individual sugars. The region on chromosome 5 associated with all three sugars is a potential target for marker-assisted selection of fruit sugar composition in watermelon.

**Standard Size Watermelon Cultivar Yield and Quality Results, North Carolina, 2017**

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Thirty-nine standard size watermelon entries from nine seed companies were evaluated for yields and quality in a study where cultivar treatments were replicated four times at the Horticultural Crops Research Station, Clinton, NC. Cultural management included growing the watermelons on black plastic mulch with drip irrigation, in-row spacing of 2.5 ft., and 10 ft. between rows (25 ft² per plant). The study was arranged in a randomized complete-block design. Ten triploid plants and four pollenizer plants (2 Ace Plus and 2 SP6) were transplanted per plot on 15 May 2017. Each fruit was harvested and weighed when ripe over five harvests; 18 and 25 July, and 1, 8 and 22 August. Marketable fruit were categorized into four size categories; 30-count (21.4 lb), 36-count (17.6–21.4 lb), 45-count (13.6–17.5 lb) and 60-count (9.0–13.5 lb). Hollow heart ratings, soluble solids, and flesh firmness were determined from 20 fruit per cultivar (5 fruits per replication). For total yields across five harvests, average yield across cultivars was 73,000 lb per acre. The top one-third yielding entries in terms of weight were ORS6260 (91,700 lb per acre), 9651HQ, 9501HQ, SV0241, Maxima, Exclamation, Crunchy Red, Bottle Rocket, Charismatic, 7197HQ, Captivation, FWT6008, and Secretariat (lowest top one-third yielder at 80,000 lb per acre). Average fruit weight across all five harvests and all cultivar entries was 15.8 lb, which is relatively high compared with previous years, but comparable to the overproduction of generally large size fruit produced by commercial growers in 2017. The largest fruit was 20.8 lb produced by ORS6260. The other 11 cultivars that produced the largest fruit (> 16.0) in descending order of development were; Joy Ride, Maxima, WDL2413, Excursion, ORS6305, Crunchy Red, Exclamation, Tailgate, Sweet Dawn, 9651HQ and Bottle Rocket. The top one-third of cultivars that produced the greatest number of fruits per acre were not the top weight per acre producers were; Charismatic, 7187HQ, ORS6253, and Unbridled. The greatest moderate to severe hollow heart resulted in ‘Pee Dee Sweet’ (31%), ‘Charismatic’ (30%), and ‘Summer Breeze’ (20%). Soluble solids ranged between 11.1–13.1, with ‘Joy Ride’, ‘Summer Breeze’, and ‘Unbridled’ being 13 or more. Fruit firmness was similar across most cultivars with the softest flesh cultivars being Pee Dee Sweet and Poseidon. The greatest percentage of smaller sized fruit (60- and 45-count) were produced by ‘7197HQ’, ‘9601HQ’, ‘Lemon Ice’, ‘Neptune’, ‘Poseidon’, ‘Secretariat’, ‘Traveler’, and ‘Troubadour’.

**Mini-watermelon Cultivar Yield and Quality Evaluations in North Carolina, 2017**

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Mini or personal size watermelons comprised approximately 15% of the watermelon market share in the United States in 2016. Several seed companies have focused part of their breeding program on mini-watermelon cultivar development. Given this interest, the objectives of this study were to determine how various mini-watermelon entries compared in terms of yield, size, and quality when grown in a southeastern U.S. environment. The study was conducted at the Horticultural Crops Research Station, Clinton, NC. Cultural management included growing the watermelons on black plastic mulch with drip irrigation, in-row spacing of 1.5 ft, and 10 ft between rows (15 ft² per plant). The study was arranged in a randomized complete block design with four replications. Eight triploid plants and four pollenizer plants (2 Ace Plus and 2 SP6) per plot were transplanted on 11 May 2017. There were 18 triploid mini-watermelon entries from six seed companies. Each fruit was harvested and weighed when ripe over six harvests which began on 11 July and ended 22 Aug., 2017. Fruits were categorized into four size categories; < 3.0 lb (not marketable), 3.0–7.0 lb (marketable), 7.1–9.0 lb (potentially marketable), and > 9.0 lb (not marketable). Rind thickness, soluble solids, and flesh firmness were obtained from 5 fruit per plot (20 total fruit per cultivar). Greatest fruit number per acre (nearly 10,000) between 3.0–7.0 lb were obtained with ‘Ocelott’, ‘Petite Perfection’, ‘Siegers B’ and ‘Skystar’ resulting in 75 to 80% fruit in this size category. When 7.1–9.0 lb size fruits were considered marketable, all but one cultivar had at least 70% of their fruit in the 3–9 lb category. Some cultivars exceeded over 90% in this category. If 7.1–9.0 lb melons can be marketed, an average of 2000 more fruit per cultivar could potentially be sold per acre. Besides the four cultivars that yield highest in the 3–7 lb category, the cultivars Skyline and WDL 0104 had yields that exceeded 10,000 fruit per acre. Rind thicknesses varied among cultivars. The cultivars with the thinnest rind (< 10 mm) were Petite Perfection and Skyview. Cultivars with the thickest rind (15 mm) were Belmont, Extazy, ORS 7009, and Siegers B. Soluble solids were generally similar with most cultivars between 11 and 12, while some of the finest flesh cultivars were ORS12745, ORS12750, Ocelott, Skyline, and Skystar. The softest flesh was obtained with ‘WDL0104’. Several additional cultivar options exist to current standard mini-watermelon cultivars like Extazy.

**Pollenizer Placement Considerations Effects on Watermelon (Citrullus Lanatus) Yield and Quality Over Two Growing Seasons**

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Pollenizers are necessary to obtain high triploid watermelon fruit
set and yields. The objective of this study was to determine the effect of a new pollinizer and its placement on watermelon yields. Two replicated studies with four replications were conducted at the Cunningham Research and Extension Center, Kinston, NC, in 2016 and 2017. The plants were grown on black plastic mulch with drip irrigation. Plots were three rows, 30 ft long, 10 triiploid plants per row, and 4 pollinizer plants per row. In 2016, there were six treatments; three pollinizer cultivars (SP6, SP7, and Sangria) and two pollinizer arrangements [pollinizer and triiploid plant (Fascination) grown in the same transplant cell (referred to as “deuce” treatment)] or interplanted where the pollinizer was placed equal distance in-row between triiploid plants (referred to as an interplant treatment). The six treatments included 3 deuce treatments; Fascination + SP7, Fascination + Sangria, and Fascination with 1/2 Sangria and 1/2 SP7. The three interplant treatments included; SP7, SP6, and ‘Sangria’. In 2017, three additional treatments were added; two deuce treatments, one with Fascination + SP6, the other with Fascination + Estrella. The additional interplant treatment included Estrella. There were 6 harvests in 2016 and 7 harvests in 2017. Each triiploid fruit was harvested when ripe and weighed. In 2016, regardless of pollinizer placement, the use of SP7 generally resulted in higher yields than all other pollinizer types and their arrangements for both triiploid fruit number and weight per acre. Lowest triiploid yields were obtained with Sangria, regardless of pollinizer placement, and resulted in about 20,000 lb per acre less than if SP7 was used as a pollinizer. When SP6 was used as an interplant treatment, triiploid yields were less than SP7 but better than when ‘Sangria’ was used as a pollinizer. The use of ½ Sangria and 1/2 SP7 in the deuce arrangement yielded similarly to the SP6 interplant treatment. Like 2016, in 2017, yields over seven harvests were greatest when SP7 was used as the pollinizer either when interplanted or planted in the hill with the triiploid. Yield response for all other pollinizer cultivars regardless of arrangement were similar, but less than SP7, the only exception being when Estrella was placed in the same hill as the triiploid (deuce) and yield were similar to SP7. Use of the SP7 pollinizer resulted in improved triiploid yield compared with other cultivars in 2016 and 2017. The use of the “deuce” planting arrangement appears to be a viable planting option.

**Hollow Heart Formation In Grafted and Non-grafted Watermelon**

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United States consumers prefer seedless triiploid watermelon to diploid (seeded) fruit. However, triiploid watermelon tends to be more susceptible to internal defects like hollow heart (HH). HH is serious defect characterized as an internal crack or void in the center of the fruit. This defect causes losses in industry as load rejection occurs if 12% of the load has HH. Proper pollination plays a crucial role in HH development; triiploid cultivars and less dense cultivars are more prone to HH; effects of rootstock are unknown. Experimental objectives were to limit the amount of viable pollen and study HH formation in grafted and non-grafted watermelon. Liberty scion, a cultivar prone to HH, was grafted onto no graft (control), Carnivor and Kazako (Interspecific hybrid rootstock (rs), C. moschata × C. maxima), and Emphasis (Lageneria siceraria, bottle gourd rs). Transplants were planted in Clayton NC with diploid pollinizers (SP-6) planted on four rows at 6, 9, and 12 in-row-spacing (three blocks/treatment row). Longitudinal cuts were made and fruit rated for HH incidence and void airspace. Firmness was measured with a FDIX penetrometer with 0.8 cm diam. probe in heart and interlocular flesh tissue spaces. Heart tissue was saved for compositional and cell size assays. Pollinizer distance did not affect HH incidence or severity; HH was higher in non-grafted or Emphasis rs. Fruit length and diameter were largest when from Emphasis or non-grafted rs. Flesh firmness was increased by 1 N in fruit of interspecific rs and fruit without HH. The soluble solids content (% SSC) was lowest in fruit from Carnivor or fruit with HH. SSC was strongly and positively correlated to pH. Fruit with HH and from Lageneria rs were higher in pH. Incidence of HH or graft treatment had no effect on fruit weight, lycopene, citrulline, or arginine content. Use of an interspecific hybrid rs increased watermelon tissue firmness, cell density and decreased HH. Fruit with lower firmness/cell density were lower had more HH. Results show that HH can be field induced in susceptible watermelon cultivars, and in contrast HH may be reduced with rs of certain interspecific hybrids.

**Comparison of Grafted and Non-grafted Watermelon Yield and Quality Grown under Conventional and Organic Cultural Practices**

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This research primarily focused on introducing grafted watermelon into organic markets. Currently there is very little certified watermelon production in the United States, capturing less than a tenth of a percent of the total market. In addition, modifying watermelon fields, by direct seeding four native wildflower species Coreopsis tinctoria, Gaillardia pulchella, Zinnia elegans and Cosmos sulphureus into the rye rows typical used as windbreaks, spray rows and harvest rows was integrated as an organic approach. A randomized completed block design was implemented in a conventional field and an adjacent organic field. Beds were set on 8’ centers and plants planted 3’ within row. Two seedless scion cultivars (Quetzali and Melody) and one seeded cultivar (Crimson Sweet) were used in a factorial combination with the following rootstocks Carnivor, Super Shintosa, and Carolina Strong Back. It appears the rootstock Carolina Strong Back outperformed Carnivor and Super Shintosa for all scions, and Quetzali benefited the most from being grafted with regard to total weight, number per acre and %Brix.
National Cowpea Improvement Association

Evaluation of Soluble Sugar Content in Cowpea Seeds

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Cowpea [Vigna unguiculata (L.) Walp] is a legume crop grown worldwide to provide protein, starch, soluble sugar, amino acid, fatty acid, mineral, and vitamins for human consumption and animal feeding. The content of soluble sugar is an important physiological trait in cowpea seeds. It does not only plays an important role in storability and abiotic stress tolerance in seeds, but also provides energy to human body, increases the tasty and mouthfeel of cooking quality. Therefore, this research aimed to evaluate variation of cowpea seed soluble sugar content, and develop different soluble sugar content cultivar(s) for cowpea costumers in breeding program. A total of 113 cowpea seed genotypes, including 89 USDA GRIN germplasm accessions and 24 breeding advanced lines in Arkansas State, USA, collected from different locations were evaluated soluble sugar using Spectrophotometer by phenol-sulphuric acid method. The results showed that the seed soluble sugar content in tested cowpea samples exhibited a wide range from 32.55 mg/g to 86.05 mg/g with an average of 54.52 mg/g, based on the standard curve $Y = 0.0039X + 0.0235$ ($R^2 = 0.99878$). The top five cowpea genotype with highest soluble sugar level in seeds are the Arkansas cultivar Empire (86.05 mg/g), USDA accession PI583202 (84.50 mg/g), Arkansas breeding advanced line 09–655 (82.05 mg/g), USDA accession PI601085 (81.60 mg/g), and breeding advanced line 09–529 (80.94 mg/g), which can be used in cowpea breeding program to develop new cowpea cultivar(s) with greater soluble sugar content. We also found that soluble sugar level in commercial cultivars and breeding advanced lines contain is higher than cowpea germplasm do. Soluble sugar content are effected by experimental locations, same genotype expressed different content in different locations. Colorful coat seeds may show soluble sugar level in cowpea seeds for costumers’ choice in the market.

Genetic Diversity, Population Structure and Genome-wide Association Study in Cowpea

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This purpose of this research is to build a molecular breeding platform integrated into a classical breeding approach in cowpea through DNA sequencing platform. Genetic diversity in 768 accessions of USDA cowpea germplasm core set was analyzed based on 1028 SNPs postulated from genotyping by sequencing (GBS) and also based on 11 quantitative traits. Results indicated that the geography grouped affected both phenotypic and genotypic variations; both data supported that the African was the original domestication place in this study; the accessions from Asia had higher diversity and closer to the cultivated cowpea; the most agricultural diversities were observed on India population, which were close to the population from Central East Africa; and the United States breeding sources were closer to West Africa and East Asia. Genome-wide association study (GWAS) were conducted using the SNPs discovered from DNA sequencing for several important traits in cowpea: cowpea mosaic virus (CPMV) resistance, bacterial blight (Xanthomonas axonopodis pv. vignicola) resistance, cowpea aphid tolerance, iron deficiency chlorosis (IDC) tolerance, low phosphorus efficiency, salt tolerance, seed protein content, seed antioxidant content, and plant habit. Meanwhile, the SNP markers associated with these traits were identified. The research will provide a tool to use these SNP markers in cowpea molecular breeding through marker-assisted selection (MAS).

A Rapid Approach for Salt Tolerance Evaluation in Cowpea at Seedling Stage

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Salinity is a major constraint affecting crop production globally. Seedling is a stress-susceptible stage in plant growth and development. Impacts of salinity on cowpea have been demonstrated to be yield reducing. Developing a rapid approach for screening salt-tolerant cultivars will help cowpea breeders to screen a large population in a relatively short period of time, thus contributing to enhancing breeding programs. Therefore, the objective of this study was to develop a rapid methodology to evaluate salt tolerance in cowpea at seedling stage in order to discriminate salt-tolerant genotypes from the susceptible ones. A total of 30 genotypes were used in this study. Two genotypes, PI582468, salt-tolerant, and PI255774, salt-susceptible, as previously reported, were used as controls for validating the methodology. The experiment was completely randomized design with three replications, and organized in a split-plot manner. Salt concentration was 200 mM. In addition to the salt-treated plants, another set of plants were irrigated with deionized water. Irrigation was conducted from the bottom of the pots in which cowpea genotypes were planted in order to assist plant roots in rapidly taking up salt compounds. Salt treatment was initiated at the beginning of V1 stage, and carried out for 2 hours daily until the susceptible check was completely dead. Results revealed that significant differences among the 30 genotypes in average number of dead plants per pot, leaf injury scores, relative salt tolerance for chlorophyll, plant height, leaf and stem biomass ($P < 0.0001$). All PI255774 plants were completely dead, whereas those of PI582438 were fully green after two weeks of salt stress. In addition, a highly salt-tolerant genotype, PI349674, was identified. Relative salt tolerance for chlorophyll content was highly...
correlated with number of dead plants and leaf injury scores\( (r = -0.77 \) and \( r = -0.79 \), respectively), indicating that the higher the number dead plants were, the lower relative salt tolerance for chlorophyll content and leaf injury scores were. Relative salt tolerance for leaf biomass was moderately correlated with number of dead plants and leaf injury scores\( (r = -0.46 \) and \( r = 0.50 \), respectively), whereas relative salt tolerance in plant height was poorly correlated with number of dead plants and leaf injury scores\( (r = 0.11 \) and 0.17). Therefore, number of dead plants per pot, chlorophyll content, and leaf injury scores were good criteria for salt tolerance evaluation in cowpea. This study provided a rapid methodology and suggested simple criteria to evaluate salt tolerance at seedling in cowpea.

**Phenomics of Cowpea at Seedling Stage under Salt Stress**

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Cowpea is an economically important legume and salinity adversely impacts cowpea growth and development. Understanding phenomics for salt tolerance in cowpea will assist in developing better phenotypes for advancing cowpea breeding for salt tolerance. However, studies on the phenomics under salt stress in cowpea remain limited. The objective of this study was to investigate the phenomics of cowpea at seedling stage under salt stress. Salt concentration consisted of 0, 50, 100, 150, 200, and 250 mM. Six cowpea genotypes, PI582468 (highly salt-tolerant genotype), PI255774 (highly salt-susceptible one), PI262179 (moderately salt-tolerant), PI582573 (moderately salt-susceptible), PI582402 (moderately salt-susceptible), and PI582697 (moderately salt-susceptible) were used in this study. The experiment design was split-plot with NaCl concentration as whole plot portion and genotype as split-pot portion with three replicates. Salt treatment was applied for 20 days. Phenomes included net photosynthesis activity, stomatal conductance, intracellular CO\(_2\) concentration, transpiration rate, instantaneous water-use efficiency, intracellular CO\(_2\) concentration/ambient CO\(_2\) ratio, chlorophyll content, leaf injury, plant height, and leaf and stem biomass. Results revealed that net photosynthesis, stomatal conductance, transpiration rate per unit area, and instantaneous water-use efficiency were rapidly affected by salt stress even at low NaCl concentration. Significant effect of NaCl concentration × cowpea genotype was identified\( (P < 0.05)\). Instantaneous water-use efficiency was significantly associated with salt-tolerance. Significant decrease in plant height and shoot biomass was observed. These results suggested that phenomes played a critical role in salt stress in cowpea. The findings will contribute toward establishing a high throughput phenomics platform for salt tolerance in cowpea, which is critical in modern plant breeding.
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