Supplement to *HortScience*

**Volume 51(9) September 2016**

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

**Northeast Region Annual Meeting**

3–7 January 2016, Philadelphia, Pennsylvania ............S1

**Southern Region Annual Meeting**

5–7 February, 2016, San Antonio, Texas ..................S11

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**ASHS Annual Conference**

8–11 August, 2016, Atlanta, Georgia .....................S61

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Abstracts of Presentations
from the
Annual Meeting
of the
American Society for Horticultural Science—
Northeast Region

presented at the
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Sheraton Society Hill

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AMERICAN PHYTOPATHOLOGICAL SOCIETY—NORTHEASTERN DIVISION
NORTHEASTERN REGIONAL BRANCH OF
AMERICAN SOCIETY OF AGRONOMY, CROP SCIENCE SOCIETY OF AMERICA, & SOIL SCIENCE SOCIETY OF AMERICA
NORTHEAST REGION—AMERICAN SOCIETY OF HORTICULTURAL SCIENCE

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Contains abstracts of oral and poster presentations from the 2016 Annual Meeting of the Southern Region of the American Society for Horticultural Science.

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For citation purposes, abstracts should be cited as follows:

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Northeast Region—American Society of Horticultural Science

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Research Posters—Student Contest

Water Relations of Trees Growing In a Green Infrastructure Storm Water Trench
R. Galanti*, S. Olshevski, and S. Eisenman
Temple University, Ambler, PA

Storm water management is a major concern for cities with outdated combined sewer systems. Uncontrolled storm water pollutes urban watersheds, and impairs the ecological function of streams and rivers. Storm water interception using urban green infrastructure (GI) installations planted with street trees will be a major contributor to improving overall runoff control. Evapotranspiration by trees should contribute greatly to diverting excess water from sewer systems. It is important to assess the performance of these trees to better understand their contributions to storm water management. This research project focuses on water relations of trees in a GI tree trench system in the Mt. airy section of Philadelphia. Acer rubrum ‘Armstrong’ and Platanus xacerifolia ‘Bloodgood’ were evaluated from May through November for stomatal conductance, leaf water potential ($\Psi$H) and leaf area index (LAI). Water relation trends were evident, and a one-way ANOVA with post-hoc Tukey HSD test showed a significant difference between stomatal conductance rates of the two species, but not within species. Analysis of $\Psi$H data was performed using a Kruskal-Wallis test rank sum test followed by Dunn’s test of multiple comparisons. These analyses also showed significant differences between the ranked data of the two species. In general, through the entire growing season, P. xacerifolia had greater stomatal conductance and lower susceptibility to water stress than A. rubrum ‘Armstrong’. This study provides some fundamental data on water relations and species performance in a GI tree trench system.

Comparing Stomatal Conductance of Street Tree Species in Traditional Tree Pits and Green Infrastructure Storm Water Trenches
S. Olshevski*, R. Galanti, and S. Eisenman
Temple University, Philadelphia, PA

Urban combined sewer systems (CSS) such as that of Philadelphia can lead to combined sewer overflows (CSO) during intense storm events. CSO generate serious environmental concern due to their introduction of untreated waste into local waters. Philadelphia’s Green City, Clean Waters initiative calls for significant implementations of green infrastructure in order to control the amount of stormwater runoff entering the sewer system. One such structure is a stormwater tree trench, which consists of soil-filled tree pits installed on top of a large gravel-filled catchment area beneath the sidewalk. Stormwater, collected through curbside inlets, is distributed through the catchment area via a perforated pipe. The trenches are designed to retain large volumes of water, with a portion eventually percolating into the soil below, and some being accessed and transpired by the trees above. In order to assess the effectiveness of the stormwater trenches in controlling CSO, it is necessary to evaluate the water relations of the various associated tree species. Stomatal conductance measures the concentration of water vapor released from tree leaves, and thus it serves as an excellent proxy for total evapotranspiration as well as water stress. The stomatal conductance of 25 trees of 13 different species/cultivars located on two blocks in the Mt. Airy section of Philadelphia was monitored from June–Oct. 2015. A Kruskal-Wallis test showed that the mean ranks of conductance data by species were significantly different. A Dunn’s test of multiple comparisons using rank sums was conducted to determine which groups/species differed significantly. The results suggest that some species may be better suited for use in urban GI trench trees than others. Two potential benefits of these species are 1) they have higher overall levels of conductance resulting in greater water movement out of the system via evapotranspiration following rain events, and 2) they may be less susceptible to water stress during periods of low precipitation. Furthermore, pairwise t-tests revealed that Koelreuteria paniculata and Prunus sargentii trees conducted significantly more water within stormwater trenches compared to traditional, isolated tree pits, whereas Quercus macrocarpa trees showed the opposite tendency. This research provides useful insight for further development of stormwater tree trenches by showing that tree species selection can influence the effectiveness of the system.

Hops (Humulus Spp.): A Potential Value-added Crop for New Jersey Farmers
Rutgers University, New Brunswick, NJ

Hops (Humulus lupulus) are herbaceous, perennial vines cultivated for their female flowers or cones, which are a critical ingredient in beer-making. A burgeoning craft brewery industry has been the impetus for the rise in demand for hops. Although Mid-Atlantic U.S. states account for an estimated 34 percent of national brewery sales, virtually no hops are grown in this region. As interest in craft brewing and sourcing local ingredients rise, a unique opportunity has emerged for Mid-Atlantic farmers to supply this high value crop. As farmers develop an interest in growing hops, it is important to understand the inputs needed to establish and grow this niche crop in accordance with industry standards. A SARE Partnership Grant-supported study was initiated at Rutgers University to establish a centrally located demonstration hopyard at the Clifford E. & Melda C. Synder Research Center for Sustainable Agriculture, Pittstown, NJ, to evaluate the performance of 10 commonly grown hop varieties. In addition, hop samples were donated from hop growers throughout New Jersey. Analysis of alpha/beta acid content by American Society for Brewing Chemists (ASBC) protocol ‘Hops-14’ and essential oil composition by ‘Hops-17’ provided the essential chemical metrics. Interestingly, major essential oil components ($\beta$-myrcene, $\alpha$-humulene and $\beta$-caryophyllene) varied within the same variety at different locations, which provides interesting implications through potential new flavor profiles for local brewers.
Assessment of the Effect of Interspecific Hybrid Hazelnut Pollen on the Nut Set of European Hazelnut in New Jersey

Rutgers University, New Brunswick, NJ

Hazelnuts (Corylus sp.) are being examined as a new potential crop for the northeastern United States. They are monoeocious, wind pollinated, and highly self-incompatible. When new nut-producing cultivars are developed and released, it is critical that compatible pollinizer cultivars are also made available. While vegetative buds and pistillate (female) flowers of European hazelnuts (C. avellana) are generally cold hardy in this region, the staminate (male) flowers can be damaged by cold, which can limit pollen production and subsequent nut yields. Interestingly, wild American hazelnuts (C. americana) and interspecific hybrids between C. americana and C. avellana with very cold hardy staminate flowers have been identified, and may function as cold hardy pollinizers. However, little work has been done to study their effects on nut yield (nut set per flower) and kernel quality when used with European hazelnuts as the nut-producing parents.

To examine this potential, six pollen parents comprised of two American, two European, and two interspecific hybrid hazelnuts were used in controlled crosses with the same set of European female parents (‘Yamhill’, ‘Santiam’, and Rutgers H3R07P25). The study was established and analyzed in a 3 × 7 factorial treatment structure with a split block design, where cultivar was the whole plot factor and pollen parent was a sub-plot factor. In March 2015, male flowers were removed and suitable branches were covered with pollen proof Tyvek® material. In April 2015, the bags were removed and female flowers were counted then hand pollinated with the specific pollens. Nuts were harvested from each cross in late August 2015, and numbers of total clusters set, nuts per cluster, and total number of nuts were recorded for each. The total number of flowers and nuts per cross were then used to calculate the average nut set (number of nuts/number of flowers) per pollen across the European parents. In general, results showed that the crosses using the interspecific hazelnut pollinizers (Nebraska #1 and Nebraska #10) resulted in similar average nut set to the European × European crosses. However, the wild American hazelnut pollens resulted in very poor nut set across all mother trees. Thus, preliminary results indicate that hybrid hazelnuts may represent effective, cold-hardy pollinizers for European hazelnut but additional pollen parents need to be tested. Further work will also include examining pollinizer effect on the physical and chemical characteristics of kernels.

Research Posters

Post-planting Biological Management of Apple Replant Disease

T.L. Bradshaw*
University of Vermont, Burlington, VT

Management of apple replant disease (ARD) after orchard planting with biopesticides is a relatively new practice. However, causative agents of ARD vary by orchard location, so specific biopesticide materials may vary in efficacy for any given orchard. Research was conducted in 2014 and 2015 to evaluate effects of commercial biopesticides on tree growth, crop yield, and nematode populations in two ARD-affected Vermont orchards planted in 2011. The first orchard is located at the University of Vermont Horticulture Research & Education Center in South Burlington, VT (HREC) with Windsor Adams loamy sand soil. A previous orchard was maintained on the planting site from 1990 through 2009. ‘Royal Empire’ trees grafted to Budagovsky 9 dwarfing rootstocks were planted in 2011 in a tall spindle training system with tree density of 2990 trees/ha. The second planting is located at a commercial orchard in South Hero, VT (SHVT) on Amendia and Kendall silt loam soils. The previous orchard was maintained on the site from 1900 to 2009. ‘McIntosh’ trees on semidwarf EMLA-26 rootstock were planted at a tree density of 852 trees per acre. At each site, three treatments were applied to five replicates per treatment in a completely randomized design. At HREC five-tree replicates and at SHVT two-tree replicates were used. Treatments included: 1) non-treated (water) control (NTC); 2) Actinovate AG at 0.84 kg·ha⁻¹ (ACT); and 3) MeloCon at 4.4 kg·ha⁻¹ (MCN). Treatments were applied as a soil injection with Rears Pak-Tank Sprayer (Rears Mfg Co., Eugene, OR) and OESCO FN-12 Root Feeding Needle (OESCO, Inc., Conway, MA) within the drip line of individual trees in the equivalent of 1800 and 1500 L·ha⁻¹ at 689 kpa at HREC and SHVT, respectively. Treatments occurred on four dates from May through July for each site in each year. Measured parameters included central leader and vegetative shoot growth, trunk cross sectional area (TCSA), canopy height and width (2015 only), number and kg fruit yield, and total nematodes per g soil, identified to genus (Meloidogyne and Pratylenchus). Data were analyzed within orchard and year by ANOVA (SAS 9.3) with Tukey’s adjustment at α = –0.05. Few differences were observed among the treatments for measured parameters. At HREC, ACT trees had greater TCSA than NTC in both years, but no differences in TCSA were observed at SHVT. In 2014, ACT-treated trees at HERC had greater leader length than NTC. Tree canopy width was greater on ACT than NTC at HERC in 2015. No differences were observed in crop yield or nematode density in either orchard.

Using Simple Sequence Markers to Confirm Parentage of the New Dogwood Cornus Kousa ‘Rutpink’ Scarlet Fire™

J. Capik*1, M. Muehlbauer1, and T. Molnar1, and P. Wadl
1 Rutgers University, New Brunswick, NJ; 2University of Tennessee, Knoxville, TN

A new dark-pink bracted kousa dogwood, Cornus kousa ‘Rutpink’ Scarlet Fire™, has recently been released from the Rutgers University woody ornamentals breeding program. Its female parent (Rutgers K187-44) is a pink-bracted selection from ‘Satomi’ × ‘Beni Fuji’; however, its male parent is unknown since it was derived from an open-pollination event. Big-bracted dogwoods are highly self-incompatible and the possible male parents of
this tree are limited to a known population of breeding selections from an isolated area. In this study, 11 simple sequence repeat markers were used to identify the most probable male parent out of a pool of 28 trees. DNA was amplified from all potential male parents and K187-44 for the 11 markers. PCR products were visualized and sized using the QiAxl® Advanced System (Qiagen), and the multilocus genotype data were binned using Microsoft Excel macro FlexiBinV2. A parentage simulation analysis was then performed using Cervus 3.0. Identification of the male parent, C. kousa KN148-7, was supported at the 95% confidence level.

The Ultra-niche Crops Project
Rutgers NJAES Cooperative Extension, New Brunswick, NJ
A grant from the NIFA Beginning Farmer and Ranchers Development Program was obtained for our project entitled “Ultra-niche Crops for The Progressive, New Farmer.” Through the project the team will teach new and beginning farmers about the cultivation, marketing and business management of farming 18 “ultra-niche crops”. We define ultra-niche as exceptionally high-value crops that can provide a significant source of income to the farmer while utilizing minimal land area. The six crops that we have already chosen to educate farmers on are: basil (Ocimum basilicum); hot peppers (Capsicum spp.); mushrooms (not yet determined); strawberries (Fragaria Xananassa); roselle (Hibiscus sabdariffa) and sweet potato vine (Ipomoea batatas). The other 12 crops must match the project criteria and will be selected by the advisory council. We will teach 3268 participants nationwide (virtually and in-person) through multiple educational resources developed during the 3-year project period. Educational programming will combine crop selection, entrepreneurship and business training—including financial and risk management, as well as diversification and marketing techniques. A series of in-person and online educational materials will be developed with guidance from the stakeholder advisory committee.

Broccoli Variety Trials In Southeast Pennsylvania
T. Elkner* and S. Bogash
Pennsylvania State Extension, Lancaster, PA
Twenty-five varieties of broccoli were evaluated in spring and fall plantings in 2014 and 24 varieties were evaluated in 2015 in southeast Pennsylvania. ‘Imperial’ was the standard. Both spring trials and the Fall 2014 trial were in bare soil; the Fall 2015 planting was done using plasticulture. Marketable head number was higher in both years in the fall plantings but overall was lower in 2015 than 2014. Marketable head number for imperial was higher than nine and six other varieties in Spring and Fall 2014, respectively, while it was only higher than three and four varieties in Spring and Fall 2015, respectively. Mean marketable head weight for Imperial was not different than most varieties in the spring for both years while it was less than eight varieties and greater than three in Fall 2014. In Fall 2015 there was no difference in mean head weight of all varieties. Broccoli growers in SE PA have many varieties available for production with acceptable yield and quality.

Effects of Abscisic Acid and Gibberellic Acid Applications on Cluster Loosening in Tight Cluster Variety Chardonnay in South Jersey
H. Gohil* and D. Ward
Rutgers University, Clayton, NJ
A trial was conducted to study the efficacy of Abscisic Acid (ABA) and Gibberellic Acid (GA,) on cluster loosening in Vitis vinifera cv. ‘Chardonnay’ at Rutgers Agricultural Research and Extension Center in southern New Jersey. A randomized complete block experimental design was employed with five blocks of six treatments. Treatments comprised of untreated control, 100 ppm ABA applied once (80% to 90% bloom), 100 ppm ABA applied twice (80% to 90% bloom and 3 d later), 200 ppm ABA applied once (80% to 90% bloom), 200 ppm ABA applied twice (80% to 90% bloom and 3 d later) and 4% GA, applied once (pre-bloom). At harvest cluster looseness of whole cluster and the number of berries per mm, the length and average berry weight of second true shoulder were measured. The untreated control had the tightest while GA, treated vines had the loosest clusters. Rate and number of ABA applications loosened clusters at the varying levels. However, neither of the PGRs (Plant Growth Regulators) affected length or the number of berries per mm of the second true shoulder. Average berry weight was higher in ABA-treated berries applied twice at the higher rate. There were several small but fully matured berries in clusters of GA, treated vines which could have increased the cluster looseness. PGRs did not cause any phytotoxicity to treated vines.

Prevalence of Male Flowers in Spring Seeded Zucchini Squash Cultivars
M.L. Infante-Casella*
Rutgers NJAES Cooperative Extension, Clarksboro, NJ
Zucchini squash yields are often hindered by the fact that female flowers will open 5–7 days before male flowers. Since male flowers are not yet opened, pollen is not able to be transported by insect pollinators to the female flowers. Hence, seeds within the developing fruit are sterile. Seeds that are fertilized produce hormones that promote fruit enlargement and uniform fruit formation. Developing fruit with sterile seeds will not form properly and may abort. Therefore, the first week of harvest may result in culled fruit that is discarded. Since harvest of commercial zucchini squash fields only lasts 4–5 weeks, losing the first week marketable fruit can dramatically reduce yield and profit. A preliminary study was conducted in spring of 2010 to evaluate the timing and prevalence of male flowers on green zucchini squash cultivars. The study contained a randomized complete-block design with three replications and six plants per plot. Eleven cultivars were seeded by hand with 2 seeds
Among various cultural systems. Equipment and material costs were consistent and usable results over time and distinct differences two year pilot study in a diversity of agricultural systems show standard chemical soil test program. Results of this method in a digital colorimeter. On a 0 to 5 scale, this biological nitrogen dioxide. The CO₂ was measured in two ways; either using a CO₂ respiration test. Four hundred standard soil samples were collected, processed and dried. Fungi and bacteria were then added compost amendments was measured by the Solvita® fertility from organic matter mineralization in the soil or from soil microbes is not typically measured. This contribution to their own nutrients such as nitrogen through mineralization by microbial Co₂ respiration results related to soil health. Evaluative parameter to their soil nutrient recommendations. Method, producers, advisers and extension agents add another dimension. Management practices such as tillage systems, cover cropping, compost amendments and chemical fertilizers. With this new assessment method, producers, advisers and extension agents add another evaluative parameter to their soil nutrient recommendations.

Enhancing Pollinator Habitat In New England

A. Papineau*, C. Neal, and R. Maccini University of New Hampshire, Durham, NH

Pollinators rely on access to abundant supplies of flowering plants from which to forage pollen and nectar for sustenance. Abundance and diversity of native bees as well as honeybees and other pollinators is supported by conserving and planting wildflowers and other forage on farms and in the landscape. Modifying management practices such as mowing and pesticide strategies also helps support pollinator health. Members of the Northern New England Pollinator Habitat Working Group (NNEPH–WG) support enhancement of pollinator habitat in the region through research, education, and demonstration. This poster provides an overview of selected pollinator habitat enhancement projects led by NNEPH–WG members.

Microbial CO₂ Respiration Results Related to Soil Health

W.J. Sciarappa*, S. Murphy, V. Quinn, and R. Barresi
Rutgers University, Freehold, NJ

Fertilizer recommendations are typically based upon a chemical laboratory analysis and estimated crop needs over the growing season. The ability of farmland soils to biologically produce their own nutrients such as nitrogen through mineralization by soil microbes is not typically measured. This contribution to fertility from organic matter mineralization in the soil or from added compost amendments was measured by the Solvita® CO₂ respiration test. Four hundred standard soil samples were collected, processed and dried. Fungi and bacteria were then revived by adding water to cause a burst of respiratory carbon dioxide. The CO₂ was measured in two ways; either using a colored gel response chart or CO₂ measurement in ppm with a digital colorimeter. On a 0 to 5 scale, this biological nitrogen contribution ranges from 5 lbs. to over 50 lbs. of nitrogen per acre, which may be deducted from total crop needs. County extension staff incorporated this biological sampling method within a standard chemical soil test program. Results of this method in a two year pilot study in a diversity of agricultural systems show consistent and usable results over time and distinct differences among various cultural systems. Equipment and material costs were $13.62 per sample; not including time and labor costs.

Research Oral Presentations

Investigation of the Physiological Effects of Heat Stress on Lima Bean (Phaseolus lunatus)

E.G. Ernest*
University of Delaware, Georgetown, DE

Heat stress reduces yields of May and early June-planted lima beans (Phaseolus lunatus) on the Delmarva Peninsula. High temperatures during flowering and pod set can result in later harvest, lower yield and split sets. Breeding heat tolerant lima bean cultivars adapted to the Mid-Atlantic region is one aspect of the University of Delaware lima bean breeding program. Using temperature controlled chambers in the greenhouse six lima bean genotypes were evaluated under hot (27 °C) and cool (18 °C) night conditions. The amount of pollen shed onto stigma and style and yield components were measured. Genotypes differed in their response to heat stress, but overall plants grown under high night temperature conditions shed less pollen onto the stigma and style. Heat stressed plants also produced fewer seeds, and fewer seeds per pod. Some genotypes produce fewer pods per plant under heat stress. Reduced pollen production and/or release accounts for some of the heat related yield loss observed in lima bean.

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This low-cost, high-tech soil test has shown promise to provide a simple and quantitative means in surveying the current status of soil health or measure impacts over time from management practices such as tillage systems, cover cropping, compost amendments and chemical fertilizers. With this new assessment method, producers, advisers and extension agents add another evaluative parameter to their soil nutrient recommendations.

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Investigating Eastern Filbert Blight Response In Hazelnut Progenies from New Sources of Resustence

P. Feldman*, J. Capik, and T. Molnar
Rutgers University, New Brunswick, NJ

The fungal disease eastern filbert blight (EFB), caused by Anisogramma anomala, is the primary limiting factor of hazelnut (Corylus sp.) production in eastern North America. Developing and utilizing resistant cultivars is considered to be the most effective disease management strategy. In this study, six new sources of EFB-resistance are examined for their usefulness in breeding resistant cultivars adapted to New Jersey. The list of sources includes: the C. avellana selections OSU 495.072 and OSU 759.010, which originate from southern Russia and the Republic of Georgia, respectively; a group of four National Arbor Day Foundation hybrids likely tracing back to C. americana ‘Winkler’; Grimo 208P and Yoder #5, related to C. heterophylla; and/or release accounts for some of the heat related yield loss observed in lima bean.

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Wider adoption of parthenocarpic cultivars is expected. Current parthenocarpic cultivars set more fruit per plant and require no bees for pollination. Parthenocarpic cultivars are grown at populations that are 50% to 60% lower than current gynoecious hybrids due to their ability to set more fruit per plant and require no bees for pollination. Parthenocarpic cultivars have been developed for commercial use and are common in protected culture. However, the use of parthenocarpic cucumbers for the pickle industry in the Mid-Atlantic has been limited due to the lack of adapted cultivars with desired processing traits. Trials were conducted at the University of Delaware from 2010–15 on advanced parthenocarpic breeding materials from four different commercial sources. Small plot research station trials from 2012–14 and large plot grower trials in 2014 showed that 2 parthenocarpic cultivars yielded equivalent to or better than standard gynoecious varieties with acceptable processing traits for once over mechanical harvest. These have been released as the commercial varieties ‘Gershwin’ and ‘Bowie’. Performance of ‘NQ5007’ and ‘NQ5543’ were more variable and excessive vine growth was an issue. Subsequent trials with Nitrogen fertilizer rates showed that these cultivars and sister breeding lines require 40% to 60% less nitrogen than other pickle cultivars. Parthenocarpic cultivars are grown at populations that are 50% to 60% lower than current gynoecious hybrids due to their ability to set more fruit per plant and require no bees for pollination. Wider adoption of parthenocarpic cultivars is expected. Current recommendations for production in the Mid-Atlantic region will be discussed.

Management of Herbicide Resistant Weeds In New York Processing Carrot Fields
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New York State produces approximately 1200 ha of processing carrots for the canned and frozen food market, with a value of roughly $9 million annually. Weeds cost growers hundreds of thousands of dollars because of improper carrot root formation, reduced yields and harvest interference. The backbone of weed control has been multiple post-emergence applications of linuron, starting with a 0.5x rate (280.2 g/ha, a.i.) when the carrots have at least one fully-developed true leaf and 1x rate (560.4 g/ha, a.i.) to carrots having three or more leaves. Pigweed (Amaranthus powellii S. Wats.) and common ragweed (Ambrosia artemisiifolia L.) have become particularly difficult to control in the 600 ha Potter muck region of Yates County, NY, where roughly 160 ha of carrots are grown annually. In 2012 and 2013, seeds were collected from mature pigweed plants that escaped management efforts. Seeds were germinated in a greenhouse, and 7–10 cm seedlings, were found to be highly resistant when challenged with different rates of linuron. In an effort to find alternative herbicides for growers to use, field trials were conducted in commercial carrot fields on the Potter muck (Palm sugar muck; approx. 25 percent organic matter) during the past three years. Pre-emergence applications of S-metolachlor (1098.4 and 1490.7 g/ha, a.i.), ethofumesate (1681.3 g/ha, a.i.), pendimethalin (1681.3 g/ha, a.i.), pyroxsulfone (112.1 g/ha, a.i.), acetochlor (739.8 g/ha, a.i.), and prometryn (2241.7 g/ha, a.i.) were tested. Ethofumesate and pendimethalin did not control pigweed whereas S-metolachlor was mediocre. The best pigweed control was achieved with acetochlor or pyroxsulfone applied pre-emergence, followed with a single post-emergence application of 420.3 g/ha, a.i. of linuron at the carrot 2–4 leaf stage. Less than 10% crop stunting was initially observed, but there was no difference in harvest yield. Prometryn was recently labeled in New York and was only tested in the 2015 trials. Concurrently, post-emergence applications of acifluorfen (16.8 and 33.6 g/ha, a.i.), fomesafen (5.6 and 11.2 g/ha, a.i.), oxyfluorfen (61.6 and 119.9 g/ha, a.i.), fluthiacet-methyl (2.8 g a.i./ha) and prometryn (1120.9 g/ha, a.i.) were tested. All post-emergence treatments in the muck trial resulted in moderate to severe necrosis to 2-leaf carrots, however this was generally outgrown and did not significantly impact yields. Data from the trials will be used to obtain new product registrations for use on carrots in New York.

ATP Swab Sampling In Fresh Produce Packinghouses
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Sanitation of product contact surfaces in a packinghouse are an important part of reducing food safety risk. Most fresh produce growers are not sampling the product contact surfaces to evaluate the effectiveness of their sanitation step. Swab sampling for both ATP and generic E. coli by Rutgers Cooperative Extension On-Farm Food Safety Team members allowed for evaluation of the effectiveness of sanitation methods used at participant farms. Recommendations were then made to improve sanitation procedures. Best management practices for product contact surface sanitation methods were developed and used to educate fresh produce growers. Five farms from New Jersey participated in the product contact surface sampling project. These farms...
varied greatly in their size, production methods, sanitation practices and commodities packed. Commodities included baby greens, onions, green beans, apples, and tomatoes. Packing line surfaces were swab sampled for both ATP 140 and generic E. coli. Swabs were taken during active packing and after the line had been sanitized. Sanitation practices included the products Simple Green®, Sanidate® and a 10% bleach spray solution. Sanitation practices in general reduced organic matter on the produce contact surface, reduced ATP levels and when generic E. coli was found reduced the number to 0. Variations in the sanitation step effectiveness were noted, particularly with the post sanitation step ATP numbers. Inconsistent use of the sanitation product is likely to blame. One farm found that its sanitation step was not effective in reducing ATP levels or eliminating generic E. coli numbers. It was determined that supervising staff were not present or were in a period of transition when ATP and generic E. coli levels on packing surfaces were not being managed properly. Fresh produce growers are encouraged to create a standard operating procedure when developing their product contact surface sanitation program. Training employees and posting directions in the work area are an important way of assuring proper sanitation methods are being used and that there is little variation in the effectiveness of the sanitation step. During times of transition it is important to consider relief staff tasks and ensure they are properly trained or supervised.

Differences In The Freezing Tolerance (LT₅₀) of Six Cranberry Cultivars Grown In Massachusetts

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Freezing injury is a major abiotic stress affecting cranberry (Vaccinium macrocarpon Ait.). While changes in bud hardiness during spring deacclimation are well known, bud acclimation in the fall is not fully understood. An experiment was designed to assess the timing of acclimation and degree of cold hardiness for terminal buds of six cranberry cultivars collected from a cranberry field in East Wareham, Massachusetts. Samples were taken from mid-September 2014, through mid-December 2014. Cranberry uprights with terminal buds were exposed to a series of freezing temperatures and then evaluated for visible damage. The temperature at which 50% of the buds are damaged (LT₅₀) across treatments was determined using the Gompertz function. The LT₅₀ temperatures declined with each successive freeze test, indicating increased freezing tolerance with declining fall temperatures. During the first week of field sampling (mid-September), cranberry cultivars had LT₅₀ ranging from –12.9 °C in ‘Early Black’ to –10.1 °C in ‘Howes’. The exception was during the first week of October when the field was flooded for harvest; during that period cold hardiness ceased but resumed its downward progression the following week. Cultivars differed in both hardness progression and degree. ‘Crimson Queen’ and ‘Demoranville’ took longer than the rest of the cultivars to recover as they needed more than one week to resume the acquisition of cold hardiness. The buds reached maximum hardiness by 19 Nov. 2014, ranging between –27.4 °C in ‘Early Black’ and –26.0 °C in ‘Howes’. These results have potential practical implications in determining whether or not frost management to protect buds should be implemented in the fall, particularly for early ripening cultivars.

What Role Do Native Cultivars (“Nativars”) Have In an Ecological Landscape?

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Recent declines in pollinator populations across North America have inspired small-scale conservation efforts aimed at supporting habitat in home gardens and across communities. To supply this growing market, local nurseries often promote native cultivars (“nativars”) alongside native straight species plant types, giving consumers the impression that they are equally effective in supporting pollinator habitat. Since little research has been conducted to determine the value of “nativars” to pollinators, I established a trial in 2015 at the Mt. Cuba Center in northern Delaware to compare Phlox species with its associated cultivars. Experimentation included measuring nectar volume and sucrose concentration to assess what effects, if any, these have on attracting insect pollinators. My data suggest that certain Phlox cultivars are superior at attracting and supporting groups of pollinators, while a majority of “nativars” have diminished ecological value. From these results, it is clear that more research is needed to establish specific lists of native plant cultivars which provide enhanced or similar pollinator benefits as their straight species analogues. Ultimately, this information can be supplied to nurseries and plant breeders to help promote a market for “nativars” that is both profitable and ecologically responsible.

Effect of New Block Co-Polymer Blended Wetting Agents on Wettability of Peat-Based Substrate and on Relative Phytotoxicity of Impatiens and Pansy

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New wetting agent formulations consisting of proprietary blends containing sulfonate acid ester ethylene oxide/proplylene oxide block copolymer blend (ACA3204-R and ACA3204-P); sulfonic acid ester ethylene oxide/proplylene oxide block copolymer blend with polyethylene glycol addition (ACA3204-2A), and AG2000M (Aquatrols Corporation, Paulsboro, NJ; 99% ethoxylated alkylphenol; 1% water) were tested for wettability of peat-based substrates and for phytotoxicity. Comparative wettability of peat-based substrate was evaluated following three wetting cycles using parameters of leaching fraction (percentage of water leached following an irrigation event) and wettability ratings (1 = poor wetting capability; 5 = excellent wetting capability). Substrate incorporation rates used in this study were 116 mL/yd² (a low recommended rate), 232 mL/yd² (a moderate recommended rate), and 464 mL/yd² (a supra-optimal rate).
rate). After a third wetting cycle, those substrates incorporated with ACA3204-R, ACA3204-P, or AG2000M at 232 mL/yd³ had higher wettability ratings than Pro-Mix HP (Premier Horticulture Inc., Quakertown, PA) control. Following wetting agent incorporations into substrates, there were no impatiens (Impatiens walleriana) shoot dry weight (SDW) or visual root health rating (VRHR) differences between Pro-Mix HP and other treatments. For pansy (Viola xwittrockiana), ACA3204-R, ACA3204-P, or ACA3204-2A incorporations into peat-based substrate resulted in decreased VRHR at 464 mL·yd⁻³ compared to the control. There were no SDW or VRHR differences between Pro-Mix HP and AG2000M-treated substrate at any rate for either pansy or impatiens. Following soaking blotters in 150 to 1200 ppm (vol:vol) solutions of ACA3204-R, ACA3204-P, or ACA3204-2A, it was determined that solutions had no effect on final germination percentage of pansy or impatiens compared to distilled water control. In general, higher rates of wetting agent increased mean days to 50% germination (DX; an inverse measure of germination rate) compared to distilled water control. In conclusion, new wetting agent formulations were comparatively non-phytotoxic at moderate rates for substrate incorporation and at higher rates for seed germination effects; ACA3204-R had similar wettability rating to that of AG2000M following the third wetting cycle.

Surveying Biological Soil Health With the Solvita CO₂ Respiration System

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Measurement of soil respiration CO₂ derived from micro and macro organisms is a potentially important tool to predict availability of nitrogen, the essential element not measured in routine soil tests. Four hundred soil test kits and supplies were utilized including a digital color reader and gel paddles from the Solvita® company—a Division of Woods End Laboratories, Inc. In 2013 and 2014, 18 representative soil sites were selected in Monmouth County, NJ; primarily farms having sandy loam soils with pH values ranging from approximately 5.1 to 6.3 and typical organic matter from 1.0% to 2.0%. Seventy-four crop fields were GPS/GIS mapped and sampled at the same location in spring, summer and fall. Six crop categories of local horticulture were annual crops, golf greens, perennial fairways, residential lawns, perennial grass crops and organic blueberry. The first year average for all color values on a 0-5 scale was 2.41 with a standard deviation of 0.69 while the second year average was 2.50 with a standard deviation of 0.51. Similarly, the CO₂ respiration values showed no statistical difference between years with values of 16.36 and 13.96 CO₂-C, respectively. Individual soil health results were characterized as marginal to moderate in less fertile areas and medium to ideal in more fertile areas. Soils growing perennial crops as organic blueberry, equine pasture, bio-energy grass or residential lawns reached respective values of 40.1, 23.9, 22.1 and 21.6 CO₂-C ppm. These values were significantly higher compared to farm soils with annual crops as vegetables and field corn reaching 14.1 and golf course greens 10.6 CO₂-C ppm. Measures of respiratory soil CO₂ serve as a potential indicator of an unmeasured nutrient contribution in sandy loam soils. With the estimated correlation of CO₂ carbon flux to predicted nitrogen contribution, an additional N production predicted for annual crops ranged from about 5–15 lb/acre annually and 20–35 lb/acre for perennial crops that could be credited toward total crop needs. These consistent, site specific results in central New Jersey over two years show promising implications for agronomy and horticulture. Farmers, advisors, extension agents and agricultural specialists may be able to add a new assessment method into their technical toolbox.

Creating Acidic Compost Using Elemental Sulfur

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Traditional compost typically has a high pH range of 7 to 8.5. Continual application of this material can cause an increase in soil pH. Furthermore, if high pH is an issue, alkaline soil amendments should not be used. Two experiments were conducted to determine the amount of elemental sulfur required to create acidic compost. Experiment one was conducted in containers in a greenhouse. Pelleted S (90% S) was blended at 6 rates (0, 0.9, 1.8, 3.5, 5.3, and 7.1 g/L) with finished compost created from wood chips, manure, green plant material and food waste. Containers had a volume of 2.5 L and were watered once a week. Compost pH was measured once per week over 150 days and there were minimal treatment differences for the first 30 days. Compost pH then began to decrease in all treatments receiving more than 0.9 grams of sulfur and this decrease continue for 60 days. At 90 days, the pH ranged from 5.5 to 8.2 and increased with decreasing S rates. In experiment two, pelleted S (90% S) was blended at 4 rates (0, 2.3, 4.6, and 9.2 g/L) with compost feedstocks on the front end of the composting process. Each treatment consisted of approximately 10 cubic meters of feedstock material. At the end of the 3 month composting process, the respective compost pH was 6.9, 6.0, 5.2 and 2.9. Results indicate that blending sulfur with compost is an effective way to lower pH. If sulfur can be blended with the feedstocks rather than the finished compost, reaction time to lower pH can be greatly reduced or eliminated.
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Phenotypic Variation of a Segregating Blackberry Population for Molecular Marker Development

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Blackberry production has been increasing recently due to breeders developing new blackberry cultivars with extended shelf life and improved flavor. This increased demand has resulted in the need for season-long blackberry production thus supporting the development of cultivars for longer harvest season including those with primocane-fruiting production. Research conducted on the molecular genetics of blackberries has been minimal, particularly when correlated to traits of economic importance. A recent publication provided a genetic map of primocane-fruiting blackberries that can be used for molecular marker-assisted breeding of blackberry. It is hoped that these results will lead to the use of molecular markers in marker-assisted breeding of blackberry, possibly to identify SSR markers for potential trait association.

Phenotypic data in molecular analysis of this population, possibly using the same population of ‘Prime-Jim’ x ‘Arapaho,’ measurements were collected from 90 seedlings that segregated for these traits. Data collected from the seedlings were then assessed for normality using the Shapiro-Wilk W test. Results showed that berry width, length, and soluble solids had a normal distribution while weight, pH, titratable acidity, and firmness exhibited a non-normal distribution. Further, there was substantial variation for all traits in the population, indicating its potential for further molecular characterization using this data. Variables that had a normal distribution likely had an adequate sample size, although trait inheritance could have impacted the distribution of the data among the seedlings. Future work will focus on using this phenotypic data in molecular analysis of this population, possibly to identify SSR markers for potential trait association. It is hoped that these results will lead to the use of molecular markers in marker-assisted breeding of blackberry.

The Effect of Winter Cover Crops on High Tunnel Tomato Physiology and Yield

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High tunnels are used for vegetable and fruit production in order to increase yields and extend the harvest season. Cover crops have been shown to reduce fertilizer inputs, increase soil organic matter, suppress weeds and disease, and improve soil quality in field vegetable production systems. However, research on the use of cover crops in high tunnels has been limited, thus validating the study of the effects of winter cover crops on tomatoes, a common high tunnel crop. This study investigated the effect of five treatments including a non-treated control and four winter cover crop species [Austrian winter peas (Pisum arvense), bell beans (Vicia faba), mustard (Brassica juncea cv. Kodiak), and Daikon radish (Raphanus sativus var. longipinnatus)], on the growth, physiology, and yield of tomato (Lycopersicon lycopersicum, cv. ‘Plum Dandy’). Tomatoes were transplanted into the high tunnel on 1 May. Beginning 26 May, weekly measurements of estimated tomato leaf chlorophyll (SPAD), leaf nitrogen (% dwt), and photosynthesis variables (stomatal conductance, assimilation, transpiration, and photosynthetic water use efficiency) were collected. Tomato harvest began 2 July and concluded 6 Aug., with total harvest weight, fruit number, and average fruit weight measured each week. The winter pea cover crop treatment resulted in significantly greater estimated tomato leaf chlorophyll and foliar nitrogen content over six weeks of measurement compared to the control treatment. When compared to the control treatment, the mustard and radish treatments resulted in significantly greater stomatal conductance, but the winter pea treatment did not have any significant difference. A numerically greater total per plant tomato yield was observed for the winter pea cover crop treatment (48% increase), however the yield data were not statistically significant among the different treatments.

The Effects of Shade on Greenhouse-grown Primocane Fruiting Blackberries

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Primocane blackberry production in the upper south is limited by high temperatures during the bloom and early fruiting period, resulting in poor fruit set and poor fruit quality. Shade may have the potential to delay bloom and flowering to a more favorable season by reducing temperatures that cause poor fruit set and quality. A greenhouse study was established to evaluate the...
effects of shade on primocane blackberry growth, physiology, and fruiting in a controlled greenhouse environment. Canes of ‘PrimeArk® 45’ were planted in 12 liter pots. At approximately 0.25m in height, one of the four following treatments was imposed with eleven single plant replications: 1) an untreated control [CK]; 2) unshaded for 30 days then shaded for 30 days [US]; 3) shaded for 30 days then shaded for 30 days [SS]; and 4) shaded for 30 days and unshaded for 30 days [SU]. After treatments ended, plants were grown without shade for 30 days. Plants in the SU treatment were significantly taller than the US while the control and SS treatments were intermediate. A similar trend was seen between the height and cane diameter with the SU treatment as the highest and US as the lowest. The SU had the highest total leaf area of all treatments and CK was the lowest. Dry weight of leaves was consistent for all treatments except for SS, which was significantly lower than the others. Shading reduced net photosynthesis measured, but plants readjusted to unshaded conditions. First bloom dates for each treatment were recorded. The CK bloomed first followed by US and SS. The last to bloom was the SU, 26 days after the CK. The US displayed nearly four times as many flowers as the SS, CK and SU when all potted plants were harvested. In conclusion, there was a delay for SS, which was significantly lower than the others. Shading reduced net photosynthesis measured, but plants readjusted to unshaded conditions. First bloom dates for each treatment were recorded. The CK bloomed first followed by US and SS. The last to bloom was the SU, 26 days after the CK. The US displayed nearly four times as many flowers as the SS, CK and SU when all potted plants were harvested. In conclusion, there was a delay of ‘PrimeArk-45®’ flower formation when 50% shade cloth was implemented and removed in the SU treatment.

Characterization of Yemeni Coffee Landraces Using Near-Infrared Reflectance Spectroscopy
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Coffee (Coffea arabica L.) has been a part of Yemeni culture for over a thousand years and it is widely accepted that Arabic coffee was first domesticated there. In recent years, the production of coffee in Yemen has remained stagnant, hovering around 300,000 60-kg bags since 2007. Issues such as political turmoil, chronic low yields, lack of standards and compliance with international parameters, land use and water scarcity, and lack of organization among Yemeni traders and exporters, has heavily weighed down the Yemeni coffee sector. Yet the coffee sector continues to be one of the most essential sources of income for more than 600,000 people across the country. There is a clear and urgent need for the advancement of Yemen’s coffee supply chain. In this study, Near-Infrared (NIR) Spectroscopy was used to initiate a project to “fingerprint” Yemeni coffee. The process creates a profile description for Yemini coffee allowing for a relatively affordable, simple, certifiable, and traceable identification method for coffee farmers and traders to use for their benefit. Samples of 111 Yemeni coffee seeds from multiple coffee growing regions (Taizz, Sana’a, Raimah, Al-Mahweet, IBB, Abyan, Dhamar, and Houdaidah) were used to create a calibration spectrum using a NIR analyzer. In addition, 64 samples were gathered from worldwide production areas including Ethiopia, Kenya, India, Brazil, Mexico, and other South American counties to create a spectral calibration for non-Yemeni coffee beans. There was clear distinction between NIR reflectance measurements spanning across coffee growing regions. The Yemeni signature profile was able to correctly predict 98% of the 64 non-Yemeni samples collected. These results show promise for the potential creation of a more sophisticated and larger database that could span from country, down to its region.

Evaluation of Harvest Time/Temperature on Postharvest Incidence of Red Drupelet Reversion Development and Firmness of Blackberry (Rubus L. subgenus Rubus Watson)
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Blackberry has become a significant small fruit in the retail fresh market in recent years. Since 1964, the University of Arkansas blackberry breeding program has worked to improve fruit quality and shipping capabilities in new cultivar developments. A major limitation in blackberry fruit is postharvest handling potential for the shipping market. Maintaining fruit firmness in storage is crucial. Red drupelet reversion (or simply reversion) is also an important postharvest disorder in which drupelets change from black to red during storage. Fruit harvests, particularly in the southern U.S., are often conducted during hot periods of the day and then berries moved to cold storage. It is hypothesized that reversion is increased when fruit is picked at hot temperatures and exposed to rapid change of temperature, which contributes to the breaking apart of cell membranes. The objective of this study was to evaluate harvest time/temperature on berry firmness and the incidence of red drupelet reversion. Eight genotypes were evaluated including commercially available cultivars and two breeding selections with a range of fruit firmness and reversion development tendencies. Fruit was harvested at four harvest times (7:00 am, 10:00 am, 1:00 pm and 4:00 pm) then stored for 7 d at 5 ºC before evaluation. Results indicated significant sources of variation were genotype and time of harvest for the variables compression (a measure of firmness) and incidence of reversion. Breeding selection A-2453T maintained high firmness and low incidence of reversion after storage compared to other genotypes. Reversion was also significantly lower at the 7:00 am harvest time compared to later harvests. These results suggest that harvest for the shipping market should be done earlier in the day to enhance fruit quality for postharvest handling in the shipping market.

Drought Tolerance of Anisacanthus quadrifidu var. Wrightii, Caryopteris xclandonensis ‘Dark Knight’, and Cuphea hyssopifolia
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Drought tolerant ornamental plants are needed to meet the
demands of green industry for sustainability as they create opportunities to improve plant productivity and reduce input costs for growers. Anisacanthus quadrifidus var. Wrightii (flame acanthus), Caryopteris x clandonensis ‘Dark Knight’ (‘Dark Knight’ bluebeard), and Cuphea hyssopifolia (Mexican false heather) were grown in a greenhouse at constant substrate volumetric water contents (VWC) of 25%, 30%, 35%, 40%, or 45% for 10 weeks. An automated drip irrigation system consisting of soil moisture sensors, datalogger, and a relay controller was used. Greenhouse environmental conditions were maintained at an average air temperature of 29.0 °C/24.3 °C (day/night) and daily light integral of 11.1 mol·m⁻²·d⁻¹. The results showed that as VWC decreased, leaf area, number of flower, and dry weight (DW) of all plant species decreased linearly. However, the reduction in the growth parameters varied among species. As VWC decreased from 45% to 25%, flame acanthus, ‘Dark Knight’ bluebeard, and Mexican false heather plants exhibited reduction in leaf area by 49, 81, and 80%; in number of flowers by 33, 27, and 71%; and in whole plant DW by 58, 68, and 76%, respectively. The chlorophyll fluorescence (Fv/Fm) and SPAD reading (relative chlorophyll content) of the tested plant species were not significant among VWC treatments. The flame acanthus displayed better drought tolerance with less growth reduction in comparison with ‘Dark Knight’ bluebeard and Mexican false heather.

**Education Section**

**Development of an Enology Certificate Program**

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An Enology Certificate Program was developed in the Department of Horticultural Sciences at Texas A&M University to educate students in the areas of grape growing, pre- and post-fermentation winemaking processes, wine etiquette, and sensory evaluation. The certificate is open to all majors enrolled in an undergraduate degree program, and it is transcript-recognized. The curriculum contains fifteen credit hours in viticulture, sensory science, enology, and organic chemistry. The decision to develop a transcript-recognized certificate rather than a non-transcripted certificate was based on the ultimate goals of the degree program and the target audience.

**Extension Section**

**Strawberry Production in South Texas**

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Newer strawberry varieties such as Benicia and Camarosa have certainly demonstrated that they yield more than the standard and traditionally grown Chandler variety (released 1983). The selection of plastic mulches is important for the South Texas region where black plastic mulch helps crops growing in the winter months of November through March yield better by keeping the soil warm. However, white and silver colored mulches have importance and should be used where the strawberry plants might be planted in the mid-November through December winter months of November through March yield better by keeping the soil warm. However, white and silver colored mulches have importance and should be used where the strawberry plants might be planted in the mid-November through December.
timeframe and where most of the harvests will be in the months of March and April. Therefore, black mulch should be used for those strawberry plantings occurring in October through mid-November. The grower acceptance of strawberries is still difficult since getting 0.5 pounds of fruit per plant is a low yield and one that may be difficult to justify in terms of growing and harvesting costs. More work is needed to help growers reach and attain that 1.25 pounds of fruit per plant yield.

Chasing a New Audience: Social Media Strategies and Challenges at the Mississippi State Trial Gardens

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Social media is an important tool for interacting with extension clientele. It offers the opportunity to promote programs and deliver content. It can be used to increase awareness of issues, services offered and opportunities to improve the client’s situation. It can also help Extension professionals reach a broader audience, including new demographics. The Mississippi State Trial Garden is a program offered by Mississippi State University Extension that is dedicated to identifying, evaluating, and promoting plants that excel in Mississippi landscapes and appeal to southern gardeners. The Trial Garden utilizes many different social media platforms to help achieve its goals, however the focus is on Facebook. This is because of the broad reach of Facebook compared to other available platforms. In 2015, 72% of U.S. adults on the internet used Facebook. That represents 62% of the adult population of the United States. The social media strategy we follow has six principles. 1) Use the data. It is critical to monitor the information provided by the platform about post performance and audience interaction and reach. 2) Use benchmarks. Find similar pages or profiles to compare your performance. Also set benchmarks based on your previous performance. 3) Post when people will see it. This helps assure that your post is near the top of your audience’s social media feed when they start browsing. Posts buried at the bottom of the feed are seen by many fewer people. 4) Post what people want. Photos and videos generate the most engagement on the Trial Garden’s pages and profiles. 5) Post enough (but not too much). Adding content frequently enough to keep your audience engaged is important, but it is easy to overwhelm them with too many posts. 6) Interact with your audience. Replying to comments and engaging personally with audience members encourages them to return and to help make others aware of your activity.

Using WeChat, a New Social Media Platform, to Reach Underserved Stakeholders

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According to 2010 U.S. Census data, Chinese American with a population of 4.7 million is the No. 1 ethnic group among Asian Americans. Among the Chinese American 25 years and older, 26% had graduate or professional degree, 26.6% bachelor’s degree and 15.6% some college education or associate degree, and among the 5 year and older, only 27.3% speak English only and the rest speak language other than English. The median household income among Chinese American is $70,183. This population is interested in plants and has discretionary income to spend. Texas (4.6%) is the fourth largest state with Chinese American population behind California, New York and Hawaii. The Chinese Americans are often underserved in agriculture extension. WeChat, a mobile messaging app developed by Tencent in China in January 2011, may help extension personnel to reach this group of underserved population. There are over 1 billion accounts (650 million active users), among which 70 million are outside of China. With more than Skype, Twitter and Facebook combined, WeChat provides mobile services including text messaging, hold-to-talk voice messaging, one-to-many messaging, video conferencing, games, sharing of location, files, photos and videos, and one-to-one and one-to-many money transfer. Messages posted on WeChat could also be liked to Facebook and Google+ accounts to reach a broader audience. Extension
Nursery Growers’ Relationships with Water: What Influences Their Opinions of Water?

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Water is a critical component of nursery production; however, recent pressure has been applied to the nursery industry to seek alternative water sources and adopt water conservation technologies to relieve water quantity and quality issues. In order to encourage nursery growers to protect water resources and to further facilitate the development of water conservation technologies for the nursery industry, this study used an indepth qualitative approach to gain an understanding of nursery growers’ relationships with water. Face-to-face interviews were conducted with 24 nursery growers across the United States. The findings indicated that water plays a variety of roles including meeting plants’ water needs, facilitating chemical use, controlling product quality, and facilitating business operations. The nursery growers felt protecting water resources was the right thing to do and could provide economic benefits to their business but was a task enforced by regulations. The nursery growers reported that their future interaction with water will include combatting water issues, engaging in the development and implementation of future government regulations, seeking additional technology and information about water conservation, and dealing with financial challenges. Based on these findings, extension educators and scientists should be aware of nursery growers’ needs and take their opinions into account when designing new technologies to alleviate growers’ concerns about integrating the new processes into their business operations. Educational programs can be developed with two primary purposes: 1) to assist nursery growers’ promotion of products to consumers based on identified knowledge or information gaps related to nursery growers’ water conservation efforts; and 2) to provide technical advisory assistance for new technologies and practices so that growers can more easily adopt the practice.

Using Extension Programs to Enhance Growers Adoption of Water Conservation and Treatment Technologies

Emmett Martin1, Alexa J. Lamm1, Laura A. Warner1, and Sarah White2

Water quality and quantity are major issues in the United States and around the world. Due to high water usage, agriculture is an area of concern. Water conservation specialists have employed various efforts that ensure growers have the proper skills and technology to waste less water. In horticulture, nursery and greenhouse operations require frequent irrigation to maintain the quality of their products. The focus of this research was to assess factors associated with the adoption of water conservation practices and treatment technologies in nursery and greenhouse operations. A series of qualitative interviews were used to uncover issues related to adopting technology. Content was analyzed based on Rogers (2003) Theory of Diffusion’s five characteristics that determine the rate of adopting an innovation that includes: relative advantage, compatibility, complexity, trialability, and observability. The findings revealed that growers are aware of water conservation technologies however, rate of adoption reflected factors including: cost, labor, and benefits to the environment. Adopting water conservation technologies was also linked to whether or not an operation had an opportunity to test technology prior to implementation. Barriers to adopting an innovation were associated with financial factors, incompatibility, and perception of traditional horticulture. These preliminary qualitative findings will be used to construct quantitative instruments that will allow researchers to make statistical conclusions.

Bringing Extension’s Earth-Kind® Environmental Landscape Management Program into the College Classroom

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It is vital that we train tomorrow’s leaders to base their decisions regarding environmental issues on unbiased, randomized, replicated university research. Principles of the Earth-Kind® Environmental Landscape Management System were chosen for inclusion in the Principles of Horticulture class curriculum at West Texas A&M University (WTAMU). Earth-Kind® research, created by Extension Specialists at Texas A&M, centers on real-world environmental landscape management and its principles encourage landscape water conservation, reduction of fertilizer and pesticide use, reduction of landscape wastes entering landfills, reduction in required maintenance, and landscaping for energy conservation. In Fall 2015, faculty from WTAMU and Texas A&M AgriLife Extension collaborated on the creation of an Earth-Kind Ornamental Grass Research Garden. WTAMU horticulture students were involved in every step of the garden’s creation, from initial design to final mulching and cleanup. For this garden, a randomized complete-block design was utilized that consisted of four blocks. The blocks were arranged in the garden in a manner that was scientifically sound and that also
created an outdoor space that was restful and aesthetically pleasing. Small beds of color-coordinated annuals were added to provide year-round color. Through this process, students were exposed to not only the environmentally-responsible principles of Earth-Kind, but also to the realization that strong scientific research can be designed in a manner that creates a beautifully landscaped area through which the public can walk. This now opens the door to conduct peer-reviewed research in public parks and gardens. Students with little or no background in horticulture gained valuable, hands-on experience in: applying compost, randomizing and planting ornamental grasses, and mulching the garden. Students gain knowledge of Earth-Kind principles in the classroom and the actual application of these principles during laboratory activities. This two-pronged approach, which engages the students both mentally and physically, proved highly effective and was well received by the students.

Merging an Industry Trade Show with a University Field Day—A New Successful LSU AgCenter Effort

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Over the last 10 years, the Louisiana State University (LSU) AgCenter has increased cooperative efforts with the nursery and landscape industry to have cooperative education and outreach efforts. Working with industry associations, like the Louisiana Nursery and Landscape Association and the Southeast Louisiana Nursery Association (SELNA), has led to successful joint field days and educational programs (plant materials conferences, certified nursery/landscape professional). The most successful of these events is the annual LSU AgCenter Landscape Horticulture Industry Field Day/SELNA Trade Show, held at the Hammond Research Station in Hammond, L.A. This event was held on the second Thursday in October in 2014 and 2015 and is scheduled for 13 October 2016. Prior to this joint effort, the LSU AgCenter Landscape Industry Field Day was held annually since 2007 at the Hammond Research Station in October and the SELNA Trade Show was held annually since the early 2000s (except in 2005) in either Folsom or Covington in October. Both events prior, and now the singular event, is limited to nursery, landscape and garden center professionals. Attendance at the LSU AgCenter field day had grown from 75 attendees in 2007 to around 150 attendees in 2013. Attendance at the SELNA trade show has fluctuated with a general trend being as many as 300 in the early 2000s during the first couple years of the show to around 135 at the most recent shows in 2012 and 2013. For the new event, the LSU AgCenter: 1) publishes a field day book with highlights of research; 2) provides typically field day tours of research plots; 3) maintains field day “stops” manned by entomology, plant pathology and weed science faculty; 4) works cooperatively with SELNA in terms of pre-event publicity; 5) works cooperatively with SELNA with on-site registration; and 6) provides space and facilities for a 25 booth outdoor trade show. The events of the day are typically arranged to allow attendees to tour SELNA booths, followed by morning research tours, followed by lunch and SELNA booth visiting, followed by additional (optional) afternoon research tours. SELNA provides lunch at the meeting, typically catered barbeque. This partnership has resulted in: 1) combining two events into one event; 2) increased attendance (joint event had 325 in 2014 and 345 in 2015); 3) participation from a six state area (LA, TX, MS, AL, GA, FL); 4) continuation of cash profit for SELNA; 5) reduced cost for the LSU AgCenter; 6) positive LSU AgCenter administrative response; 7) industry professionals attending the event that had not been to prior events; 8) ability to complete impact surveys; and 9) increased visibility for the LSU AgCenter with SELNA members and others.

Discovering the Value of Social Media in Horticulture Research and Extension
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Many of us are challenged to find ways to better disseminate our research and Extension findings. Administrators, legislators, and the public are demanding to know our “impact.” Thus, using all available tools to our advantage makes sense. Reach and engagement may be fairly small; yet, in context, what does small mean in social media? To put it in perspective, there are people that could be reached if only we choose to participate. Blogs are a great way to communicate research in ways that traditional journals cannot. An enticing aspect of online blogs is that the author is not limited to only text. Color photos, video, and audio are all now in play. Someday, more academic journals will catch up with these “advancements” but even so, blogs allow the communication to be more intimate between researcher and interested public. Social media allows one to condense information, make it more digestible, and more relatable. There is an enormous need to combat the torrents of misinformation that foment inside the social media world. Ultimately our job as scientists is to educate the public and advance science. With social media we can do both. Some obvious benefits are to reach a larger audience, provide a service to the university/department/program, and also further educate oneself. The benefits will become apparent with time and engagement. What doesn’t seem so obvious now may allow a career to grow into another direction.

Earth-Kind® Landscape Design and Management Schools
Allison Watkins*1, Jeff Floyd2, Fred Hall3, and Elizabeth Moore4

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An attractive home landscape adds significant value, as well as personal enjoyment, to the property, but many homeowners...
are unaware of basic planning and management techniques to achieve success. Earth-Kind® Landscape Design and Management Schools are conducted in San Angelo, Midland/Odessa, Dallas, Georgetown, and Canyon, TX, to provide homeowners the skills necessary to design, plant, and manage a landscape that is beautiful, low maintenance, tolerant to heat and drought, and the ultimate in environmental responsibility. To illustrate the impact of adopting the Earth-Kind approach, multi-year research shows that, in the absence of rose rosette, outstanding Earth-Kind roses can be grown with an estimated 94% reduction in irrigation, 100% reduction in fertilization and pesticides on the desirable plants, and an estimated 96% reduction in maintenance. The Landscape Schools are in-depth programs with typically four unique sessions that provide extensive landscape design and management information, as well as a 30-minute personalized landscape design consultation for each household. Every year, the schools achieve positive results in each city where they are held. The attendees of the most recent school held in San Angelo reported that 100% intended to select plants based on water conservation, 100% intended to use mulches more effectively, 90% intended to decrease use of pesticides, and 88% intended to modify soil for water conservation. Knowledge gained at the event was reported as 146% increase in understanding of how to prepare and use compost, 138% increase in understanding of appropriate plant selection to better conserve water, and 100% increase in understanding of how to more effectively use mulch.

**Floriculture, Ornamentals, and Turf Section**

**Biosolids Influence Growth and Quality In Field-grown Kale, Petunia, Dianthus, and Swiss Chard**

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Biosolids are a type of soil amendment processed from municipal sewage sludge. They vary in quality by municipality and processing technique. Because of the possibility of contaminants such as heavy metals and human pathogens, biosolids are regulated by the U.S. Environmental Protection Agency to ensure safety for land application. Although approximately 60% of biosolids are land applied throughout the United States, almost no biosolids are land applied in Mississippi. The City of Clinton, MS, produces USEPA Class A Exceptional Quality (EQ) biosolids, but their effect on plant growth has not been determined. We tested four field application rates (2, 8, 14, and 20 tons/acre) of biosolids, and a conventional and a slow release fertilizer at recommended rates. Dianthus, kale, petunia and Swiss chard were grown and measured for response. Soil analyses revealed that the higher rates (14 and 20 tons/acre) significantly increased soil organic matter, phosphorus, zinc, sulfur and sodium levels, while decreasing pH. The changes were mitigated over 16 days after the initial soil tests. Plants growing in ≤ 14 tons/acre biosolids responded similarly to plants fertilized with conventional or slow release fertilizer. The 20 tons/acre application rate produced stunting and symptoms of chlorosis on leaves. The lowest biosolids rate (2 tons/acre) resulted in higher average flower counts than other biosolids application rates and counts were comparable to those from the other fertilizer sources. Biosolids from this municipality can serve as a viable replacement for fertilizer applications in field settings.

**Tea as an Alternative Crop for Mississippi**

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Tea is the second most consumed beverage in the world after water. In 2014, over 80 billion servings of tea were sold in the United States, the vast majority of which were imported. Tea plant, *Camellia sinensis*, is an evergreen shrub and could potentially be a long-lived and high value perennial crop for the southeastern United States. Nitrogen (N) is a critical nutrient for plant growth. Increasing costs of inputs require recommendations for optimal N application in tea plant nursery production. The objective of this research was to determine the economic optimum application rate of N in nursery production of *C. sinensis*. One-year old liners of *C. sinensis* were planted in trade gallon containers using pine bark substrate, and plants were pruned to a uniform height and width. Each plant was top dressed with potassium, phosphorus, and micronutrients. Plants received top dressed treatment of either 0, 2, 4, 6, or 8 g N as a controlled release fertilizer (40–0–0, Florikote Advantage, Florikan E.S.A. LLC, Sarasota, FL). Ten single container replications per treatment, in a completely randomized design, were grown in a greenhouse under natural photoperiod from June 2014 to November 2014. At treatment termination photosynthetic rate, plant growth indices (PGI), root length, root area, leaf area, and tissue dry weights were determined. Tissues were analyzed for nutrient concentration. Plants treated with 2g N had similar PGI, dry weight, root area, root length, and leaf area compared to plants that received higher N rates. In general, plant N concentration increased with increasing N rate. Plants treated with higher N rates had higher net photosynthetic rates.

**Using Biochar and Vermicompost as Greenhouse Substrate**

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Biochar made from a proprietary process had promising results as container substrate from previous trials when mixed with commercial peat-based substrate. In this experiment, biochar (B) was amended with compost (C) or vermicompost (V) at 10%, 20%, and 30% (by volume), respectively, to grow pepper (*Capsicum annuum* ‘Bell Redskin’). Plants were transplanted in 15-cm azalea pots at 3 true leaf stage and grown for 16 weeks.
All plants were fertigated with 200 ppm 20N–20–12K starting on 6DAP. Plants started to flower between 51 and 53 days after transplanting (DAP). Plants grown in commercial peat-based substrate (control) had the highest biweekly growth index after anthesis, compared to 100% biochar or biochar amended with compost (BC) or vermicompost (BV). At 72 DAP, plants grown in 80B20C and 70B30C had the lowest SPAD reading photosynthesis rate. At both flowering (72 DAP) and final harvesting stage (113DAP), control had the highest dry weight of stem, leaf, and shoot. Stem, leaf, fruit, and the total shoot dry weight all increased with increasing percentage vermicompost at 72 and 113 DAP. The final yield at 113 DAP was correlated to the leaf area during flower stage at 72 DAP. The growth and yield in plants grown in biochar, BC and BV may have been affected by the low EC during the first 10 weeks, as biochar has been found to absorb high concentrations of nitrate in literature.

What Happens When the Tap Goes Dry: A Garden’s Last Lesson?

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As water becomes a scarce commodity due to a range of issues from climate change to development driven increased demand, a premium will be placed on landscapes that conserve irrigation water or better still thrive on native rainfall. In Fall 2011, severe budget cuts forced a transfer of the Texas A&M University Horticultural Gardens from maintenance by departmental personnel to maintenance by university grounds crews. Shortly thereafter maintenance was again transferred to a commercial outsourcing company. The result was a cessation of irrigation and reduction in maintenance to a few periodic mowings and little or no weeding over about 4 years. During that time the region experienced one of the longest, most severe droughts on record. This left an opportunity to assess what plants survived, thrived, or died in an untended state. In October 2015, images of the garden and surviving taxa were collected and generalizations drawn based on observations. Among the few trees and shrubs that truly thrived in the drought were several native woody taxa from Texas and the Southwestern USA, various members from the family Arecaceae, Dactylanthes (Raf.) H. Rock and Lycoris Herb., Lagerstroemia L., Vitex agnus-castus L., Zephyranthes Klatt, and Ligustrum L. Some such as Lagerstroemia L., and Vitex agnus-castus L. survived through annual summer defoliation. Few herbaceous annuals or perennials survived other than wildflowers, weedy forbs, Cynodon dactylon (L.) Pers. and Zozzia Wild. A few introduced geophytes in the genera Narcissus L., Dieteria Salis. ex Klatt, Leucojum L., Lycoris Herb., Rhodophiala C. Presl, Zephyranthes Herb. persisted. Native wildflowers such as Helianthus annuus L., Helium amaran (Raf.) H. Rock and Lupinus texensis Hook., thrived in open areas, whereas Malvaviscus arboreus var. drummondii (Torr. & A. Gray) Schery and Phyla nodiflora (L.) Greene spread in shadier spots. Also note that lacking maintenance, any wood infrastructure quickly deteriorated, while stone hardscape endured most effectively.

Summer 2015 Bedding Plant Evaluations at the University of Arkansas

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Thirty-four summer annuals representing 10 different genera were evaluated for Summer 2015 landscape performance at the Division of Agriculture Research Center in Fayetteville, Arkansas. Criteria of interest included heat and drought tolerance, ease of establishment and overall aesthetic appearance under minimum supplemental (< 25 mm/week) irrigation after establishment. The overall visual landscape impact was rated on a scale from 0 to 10 with any rating over 5 having satisfactory performance. The percent flower cover (%) of the total canopy, where applicable, was determined and a growth index was measured by multiplying plant height by two width measurements at 90˚ angles to obtain an approximate plant volume in cm³. Data were taken every other week from planting in mid-May until the first of September, the usual end of summer bedding in Northwest Arkansas. Top performers were ‘Serenita Pink’ and ‘Serenita Sky Blue’ cultivars of Angelonia angustifolia from Ball Pan-American Seed with a visual rating of 10 at maximum heat and drought stress and 100% flower cover. Other superior performers were two cultivars of coleus Solenostemon scutellariae ‘Chocolate Covered Cherry’ and ‘Lime Delight’ both from Ball Pan-American. Both had an overall average rating of 9 and a flowering percentage of 0 during the main season, which is desirable in coleus. ‘Lime Delight’ was also noteworthy in that it maintained a lime-green leaf color resisting fading and leaf scorch enduring full sun and high temperatures. The 7 cultivars in the Hot Pak French marigold series Tagetes patula suffered plant replication loss during the establishment phase because of a 200 mm rain event over 14 days. Surviving plants recovered and performed well but only averaged a visual impact rating of 5 because of dwarf habit. This series of marigold, under our conditions, is too compact and would require a commercially unacceptable planting density for bedding out and more suited for container planting.

Counting the Costs: Developing a Tool to Help Ornamental Growers Understand the Costs and Benefits of Water Recycling Systems At Their Operation

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What drives growers to make changes at their operation? Saving time or money is most important for some, while for others it could be reducing environmental impacts or improving consumer
perceptions. Helping nursery producers understand current practices and modify them with operation-specific information is critical to addressing this question. Models can help growers address questions specific to their operation. Models can demonstrate the impact of current practices and predict the impact of changes in terms of cost, labor, environmental benefits etc. A disinfection model is the first in a series of models currently under development that are designed to simulate what happens when irradiation water is recycled. The model series will incorporate research data and operation-specific information to inform growers about the impacts (and benefits) of current and prospective practices. An important caveat is that models are valid only to the extent of their underlying data. Model assumptions, input parameters, and any data gaps need to be identified, and guidance for their use provided. This model series uses the Stella® framework because of its ability to simulate responses over time, facilitate the development of models of varying complexity, its user-friendly interface, and the ability to publish and download completed models from an internet library. The models being developed will function both independently or sequentially. The overarching goal of this model series is to help assess the impacts of current practices, and understand how changes may impact operation. Additional models will assist in the understanding of pond dynamics, irrigation and runoff dynamics, nutrient uptake and loss, pesticide movement, and plant pathogen proliferation. Models for water treatment systems (e.g. vegetated buffers, floating wetlands) will also be developed and tested using field monitoring data.

**Crapemyrtle Bark Scale (Eriococcus lagerstroemiae) Monitoring at College Station, Texas**

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Crapemyrtle bark scale (CMBS), *Eriococcus lagerstroemiae* has rapidly spread throughout Southeastern and Southwestern states (Texas, Louisiana, Arkansas, Tennessee, Oklahoma, New Mexico, South Carolina, Alabama, Mississippi, and Virginia TX, LA, AR, TN, OK, NM, SC, AL, MS, and VA), which has threatened the utility, aesthetics and health of crapemyrtle in urban landscapes. It is becoming increasingly important to determine the population dynamics of CMBS throughout multiple growing seasons, which is critical to elaborate on time for treatment before their active phases to prevent unacceptable damage in landscapes and nursery container production. The number of early stage CMBS crawlers was monitored weekly using double-sided removable sticky tapes from March 6 to December 22 2015 on 12 crapemyrtle plants at four different locations in College Station, TX. The results showed that there were four peaks of crawler activity in College Station, including March 27, May 8, June 26 and October 2. The greatest number of CMBS appeared around May 8. The upper and lower branches had the same trend. Therefore, the implementation of management strategies for CMBS infestations should be earlier than May 8 to prevent or reduce the tree damage in College Station, TX. The number of crawlers of locations 3 and 4 was higher at the first and second peaks (March 27 and May 8) compared to locations 1 and 2, which might be due to the heavier original infestation. The number of crawlers of locations 3 and 4 decreased significantly with the presence of twice stabbed lady beetle, one of natural predators of CMBS. The activity of CMBS crawlers could be affected by previous infestations and natural predators, and the growers and gardeners should consider these factors before they make management strategies.

**Determination and Validation of Integrated Nutrient Diagnostic Norms for Greenhouse Rose Crops**

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Among ornamental crops, greenhouse-grown cut roses are an intensively managed cropping system, receiving rather large water, fertilizer, agrochemicals and labor inputs. With the objective of contributing to the optimization of fertilizer use while sustaining productivity and minimizing production costs and environmental impacts, we are conducting studies to establish and validate norms for integrated nutrient diagnosis techniques in this crop. DRIS (Diagnosis and Recommendation Integrated System) and CND (Compositional Nutrient Diagnosis) norms for cut roses growing on soil beds within greenhouses in the Bogotá Plateau, Colombia were generated from a database of plant tissue and soil analyses from rose cultivars grafted on *R. x ‘Natal Briar’*. Theoretical validation proved that the generated norms are suitable for crop nutrient status diagnosis, allowing for the correlation of nutrient balance indexes with crop flower productivities across a range of cultivars and plant ages. It was also determined that the use of these diagnostic norms could be extended to rose crops growing under other rootstocks, production and environmental conditions and management. A greenhouse experimental study was also conducted to validate the practical utility of these norms to optimize the fertilization of commercial crops. The diagnosis systems DRIS and CND highlighted nutrient excesses and deficiencies in this experimental crop, specifically for the micronutrients iron, manganese, copper and zinc, and which were not detected by conventional critical nutrient range methodology. The application of adjustments to these elements in the fertilization program over two flushes of growth and flowering, based on the DRIS results, improved the nutritional balance of the crop and the productivity variables of stem length and leaf chlorophyll readings.

**Gas Exchange Response to Leaf Excision for Two Field-grown Quercus Species**

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Gathering field leaf gas exchange data is essential for many research projects, and with current gas exchange systems gathered data is accurate and precise. However, due to the length of time required to make each measurement, researchers are limited on the number of data samples they are able to collect. To help increase the number of samples collected, our research objective was to determine if gas exchange of field grown excised oak leaves were different when compared to gas exchange of leaves remaining on the tree. In 2002 two species of oaks (Quercus muehlenbergii and Q. robor) were field planted in a randomized block design. Throughout the life of the trees, all trees had been drip irrigated. On one occasion in 2013, and on one occasion in 2014, auto program mode was used on two Li-6400 XT machines to simultaneously measure gas exchange on leaves from the same tree (measurements were recorded every 30 seconds). After 120 seconds, one leaf was excised and auto program continued an additional 8 minutes. Gas exchange means (n = 12) for excised and non-excised leaves were graphed over time. In addition, gas exchange means at 60, 90, 120, 150, and 180 seconds after auto program began were exposed to ANOVA, and means were separated by Fisher’s Least Significance Difference procedure. Data indicate gas exchange for un-excised leaves of each species remained fairly stable during the measurement period. In contrast, gas exchange parameters (leaf to air vapor pressure deficit, stomatal conductance, and photosynthetic rate) for excised leaves of each species decreased during the measurement period. However, data indicate there is approximately a 60 second “window” were excised leaf gas exchange is not different from gas exchange measured prior to leaf excision. Using the leaf excision technique it is possible to measure 60 leaves each hour with a single Li-6400 XT. Therefore, it appears leaf excision might be a technique researchers may use to increase sample size for field collected gas exchange data.

**Genetic Diversity of a Range of Taxodium distichum Genotypes and Cultivars Based on ISSR Markers**

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Taxodium is in the cypress family, Cupressaceae, one of several ancient genera in the family commonly known as cypresses. Once three separate species under the genus, we are accepting Taxodium as one species with three botanical varieties: 1) Baldcypress, BC; Taxodium distichum (L.) Rich. var. distichu, 2) Pondcypress, PC; T. distichum var. imbricarium (Nutt.) Croon, and 3) Montezuma cypress, MC; T. distichum var. mexicana Gordon. In recent years, Taxodium has found favor in coastal windbreak forest, tidal land, and bottomland restoration projects, as well as being a modestly popular deciduous shade tree. The species is appreciated for tolerance to flood, salinity, alkalinity and hurricanes. In this research project, the genetic diversity of the three botanical varieties (BC, PC and MC), the purported hybrids from China, and ‘Dongfangshan’, a clone promoted as a hybrid of Taxodium and Cryptomeria in China, was analyzed. Samples were evaluated by Inter-Simple Sequence Repeat (ISSR) markers. A total of 135 individuals produced 108 bands when amplified by using nine ISSR primers. The Nei’s gene diversity (h), the Shannon’s Information index (I) and the Percentage of Polymorphic Loci (PPL) between different genotypes of BC were 0.2581, 0.3931 and 87.96%, respectively. For PC, the values were 0.2278, 0.3445 and 72.22%, respectively. For MC, the values were 0.2068, 0.3120 and 61.11%, respectively. Gene differentiation analysis showed that the gene flow (Nm) and coefficients of gene differentiation (Gst) of the three taxa were 0.7189 and 0.1955 for BC, 0.2696 and 0.2942 for PC, and 0.9861 and 0.0071 for MC. This study reports high genetic diversity between the genotypes of Taxodium, but less noticeable diversity within. There was less genetic exchange between genotypes in Taxodium that will lead to population differentiation. Data confirms that the parents of the purported hybrids were MC and BC. Finally, our data indicates ‘Dongfangshan’ does not appear to be a BC x Cryptomeria hybrid.

**Growing Roses in the Bayou State—Researching, Promoting, Trialing**

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The LSU AgCenter has been active in rose research trials for many years. In addition, the LSU AgCenter has included roses in its Louisiana Super Plant program along with promoting roses of the year in cooperation with the Gulf District of the American Rose Society. Rose research is conducted at the AgCenter Botanica Gardens at Burden in Baton Rouge, the Hammond Research Station in Hammond and at the Gardens of the American Rose Center in Shreveport. Rose work on-going at the current time include the American Garden Rose Selections (AGRS) program, American Rose Trials for Sustainability (ARTS), compact dwarfs EarthKind trials, cultivar evaluations of Kordes, David Austin and Easy Elegance roses, and evaluations of selections from Conard-Pyle/Star Roses and Plants. My Hometown Roses from Conard-Pyle will be included in trials starting in February 2016. Debut AGRS winners (2016) are Dee-Lish, Looks-A-Likes Phloxxy Baby, and Thomas Affleck. AGRS 2017 winners have been decided and these will be publicly announced in March/April 2016. Louisiana Super Plant roses include Belinda’s Dream and the Drift series (coral, pink, red, apricot, sweet, popcorn, white and peach). Some of the new Kordes cultivars performing well include Beverly, Wedding Bells, Grand Amore, Winter Sun, Sunny Sky, Summer Sun and Pink Enchantment. My Girl is the best Easy Elegance rose in LSU AgCenter trials. The Gulf District-American Rose Society “Rose of the Year” program debuted in 2015. These roses are publicized with support from the LSU AgCenter. The 2015 winner was Belinda’s Dream with Cinco de Mayo being named the 2016 winner. The LSU AgCenter continues to recommend, promote the Easy Tea hybrid tea rose winners from a 4-year research project at the Gardens of the
New blackberry cultivars and selections from the University of Arkansas Fruit Breeding Program were evaluated to determine changes in composition and fresh-market attributes of blackberries during postharvest storage. Berries were harvested at the shiny-black stage and measured before storage and after storage at 2 °C and 90% RH for 7 d. Twelve genotypes (‘Natchez’, ‘Osage’, ‘Ouachita’, ‘Prime-Ark® Traveler’, A-2416; A-2418; A-2434; A-2450; A-2453; A-2491; APF-268) were included. Berries for storage and subsequent postharvest analyses were placed in 240-g vented clamshells in triplicate. Firmness, soluble solids (SS) and titratable acidity (TA) were evaluated before and after storage, and percent unmarketable fruit and incidence of red drupelets were evaluated only at Day 7. Storage for 7 d did not affect firmness or soluble solids of the blackberries evaluated. A-2453 was the firmest (9.6 N) and ‘Osage’ and ‘Ouachita’ the softest (4.8 N). A-2491 had the highest SS (10.9%) and A-2418 the lowest (6.6%). The TA of A-2418, A-2434 and ‘Ouachita’ decreased during the 7 d of storage. A-2418 was the most sour (1.49% TA) and A-2453 was the least sour (0.53% TA). After 7 d of storage, A-2416 had the highest incidence of red drupelets (15%) and A-2453 the lowest (0.0%). ‘Natchez’ had the lowest percent of unmarketable fruit (1.45%) and A-2418 the highest (53.6%).

Small Scale Pomace Handling Systems for Value Added Product Generation from Grape Winery Waste

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Grape (Vitis vinifera) pomace represents an underused co-product (14% to 20% of wine grape throughput) of wine production in Oklahoma. Wine grape production and wine manufacture in the state is small in comparison to many other wine-producing states, necessitating development of small scale systems for handling and processing the pomace resource. Our project evaluated various components of grape pomace (skins/pulp, stems and seeds) for value recovery. Steam distillation was assessed for pomace volatile chemical (essential oil) recovery; while volatile recovery was feasible, recoveries in the range of 60 to 120 µg·g⁻¹ were anticipated to be too low to drive profitability. Seed components of pomace were good sources of oil (12% to 14%, w/w) and grape seed flour had value as a food ingredient or as a feedstock for grape seed extract generation. Small scale equipment was tested for initial pomace seed separation (modified trommel seed cleaner), ambient temperature drying (custom low cost drying chambers), final seed cleaning (vibratory screen separator), oil expression (single head oil press), press cake-to-flour handling (hammer mill, stone flour mill) and oil clarification (filter press). Total equipment cost was approximately $40,000 and estimated income potential per ton of pomace was $900 to $3,000.

Criscy Blackberry Fruits: Their Morphological Components and Postharvest Potential

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The University of Arkansas blackberry breeding program was
begun in 1964, and since then the program has released cultivars with the aim to provide high-quality fruit to the fresh-market industry. A trait for successful blackberry (Rubus subgenus Rubus Watson) postharvest handling is flesh firmness, so developing cultivars with high firmness is a top priority for the majority of breeding programs. In particular, the Arkansas blackberry program has a wide range of genotypes with exceptional firmness characteristics, including fruit with a unique crispy texture and firmness. During 2013 and 2014, fruit firmness measurements were done on 15 crispy and non-crispy Arkansas genotypes. Firmness measurements consisted of fruit compression, skin drupelet penetration, and receptacle penetration. Also, color reversion was evaluated among these genotypes after storage. Finally, in 2014 confocal photos were taken on sections of berries of a subset of crispy and non-crispy genotypes. Compression force values differentiated crispy and non-crispy genotypes, with average values of 11.8 N and 8.0 N, respectively. Drupelet penetration force was also higher for crispy genotypes averaging 0.23 N and non-crispy 0.15 N; similarly, receptacle penetration force averaged 0.20 N for crispy and 0.18 N for non-crispy genotypes. Significant interactions of storage by texture were observed only in fruit compression. Visual inspection of fruit mesocarp revealed that drupelet cells and cell walls of crispy genotypes maintained their structure during ripening and did not break apart, while non-crispy genotypes did not maintain their structure and cellular integrity. Color reversion is a postharvest disorder in which drupelets of blackberry fruits turn red after being black at harvest. Therefore, this trait, it has a negative impact for growers, shippers, and consumers. After storage at 5 °C for 7 d, crispy genotypes expressed low levels of reversion compared to non-crispy genotypes. For crispy genotypes, 13.2% of drupelets developed color reversion, whereas a 41.0% developed this disorder in non-crispy genotypes. These results are important since it was determined that crispy genotypes have an improved firmness before and after storage, their cells do not break apart during ripening, and have a better postharvest potential.

Watermelon as a Means to Boost Citrulline in a Rice-based Diet in Senegal
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Rice is a staple food in Senegal, and watermelon is a commonly grown fruit. Sarcopenia (muscle wasting) is a problem in the elderly population in countries where pharmaceutical control is limited by economy and access. Citrulline, an amino acid in watermelon, is known to help prevent sarcopenia. In this experiment, watermelon was used with rice to develop a rice product with improved citrulline content and as a means of preserving watermelon. Paddy rice was parboiled in the presence of watermelon or water at temperatures of 70, 80, or 90°C. Following cooking, rice was allowed to sit in the solutions for 18, 19, or 20 h, then washed and solar dried to 12% moisture to inhibit bacterial growth. Rice samples were sent to Kannapolis NC for HPLC analysis of citrulline and arginine content. Citrulline and arginine content were determined from dehulled rice that was ground to a fine particle size, extracted with acidified water, and determined by HPLC. The citrulline and arginine content of rice in the presence of watermelon showed a strong increase in citrulline compared to rice or rice soaked with water (0.6 vs. 15.3 mg/100 g dry wt). There were effects of cooking temperature, and soak time on citrulline content. The highest amount of citrulline was found in rice heated to 80 °C and soaked for 18 h with ‘Kaolak’ watermelon (33 mg/100 g dwt). In contrast, ‘Sugar Baby’ watermelon yielded highest citrulline contents at 70 or 80 °C when soaked at 18 or 19 h (23–27 mg/100 g dwt). Future work with watermelon fortified rice will focus on consumption and bioavailability of citrulline.

Stable Pigments for Muscadine: What Components Will Slow Wine and Juice Browning?
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Muscadine grape (Vitis rotundifolia) is native to the southeastern United States. This seeded grape typically has a thick skin and mucilaginous flesh although new fresh market types have a non-slip skin and crisp or firm texture, more typical of a non-seedless table grape. Muscadine is widely valued for wine and juice, imparting a unique flavor and aroma but color is unstable due to oxidation of the diglucoside pigments, which make up 90 to 100% of the anthocyanins in muscadine, compared to 0% in V. vinifera. Additionally, the type of diglucoside pigment is important as malvidin and peonidin are less vulnerable to oxidation than delphinidin, cyanidin, or petunidin. Delphinidin is the predominant pigment in most muscadine cultivars, although high amounts of malvidin can be found in some parental breeding material. In this experiment, the advanced selections from three breeding programs were screened for type and amount of anthocyanin pigments. Material from Georgia utilizing crosses of Fennel 3-way hybrid with a true muscadine yielded a high percentage of selections having a total pigment content of 70 to 80% malvidin and peonidin 3,5 diglucoside. Selections from a cross of true muscadine with a munsoniana genotype yielded a high number of selections with fruit having 30 to 60% malvidin 3,5-diglucoside and peonidin 3,5-diglucoside. Based on these results and of previous work by other researchers, a target of malvidin 3,5-diglucoside plus peonidin3,5-diglucoside making up at least 40% of total pigments would be desired to slow or prevent wine browning. The presence of malvidin monoglu-
Vegetable Crops Section

Introgressing Novel Traits Into Pepper from Capsicum baccatum

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The pepper breeding program at Texas A&M AgriLife Research has a 45 year history of developing novel germplasm and cultivars that resist abiotic and biotic stresses. This effort resulted in release of eleven cultivars of hot and sweet peppers with multiple virus resistance genes. The primary focus of the program now is to exploit interspecific hybridization between Capsicum annuum and other species (Capsicum baccatum, Capsicum chinense) for novel trait introgression. Over the last 15 years, these efforts have led to discovery of previously undescribed traits, including dominant resistance to Tobacco Etch virus and powdery mildew, resistance to multiple species of aphids, and freezing tolerance. Inheritance patterns for the two resistance traits fit best to single dominant gene models within four families. Inheritance for aphid resistance and freeze tolerance are under investigation currently. Development of SNP markers linked to the resistance genes is underway using backcross populations. Characterization of other novel traits, such as uniquely firm fruit and enhanced fruit volatiles and aroma, is also in progress. Additional abiotic stress tolerance traits are being evaluated, including drought tolerance due to enhanced root growth, and nutrient use efficiency. An additional effort to characterize resistance to leafminer from C. baccatum is underway, with several years and locations of data collected. In response to the growing threat of resistance gene breaking strains of bacterial leaf spot (BLS), an emphasis has been placed on selection for horizontal or race insensitive resistance to this disease. Multiple inbred lines, derived from crosses with C. chinense, demonstrating broad spectrum BLS resistance have been developed. These are all serrano and jalapeño types, but development of additional fruit types is underway. The first new cultivar derived from this effort will be released in 2016—a serrano pepper with powdery mildew, virus and bacterial leaf spot resistance.

Performance of Sequentially Transplanted Bell Pepper in Organically Managed High Tunnels in Hardiness Zone 7&8

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High tunnels are effective tools in achieving season extension of vegetable crops. Bell pepper has been proven to be a profitable crop in high tunnels in the Midwest. However, information on its production in hardiness zones 7 & 8 of North Carolina was very limited. The objective of this project was to determine the best time for planting bell pepper in high tunnels for both spring and fall seasons and to explore the economic potential of the crop in organic managed high tunnels. Bell pepper ‘Sweet Sunshine’ (yellow fruit) and ‘Olympus’ (red fruit) were tested in high tunnels (30’ x 96’ x 5’) located in Greensboro (zone 7) and Goldsboro (zone 8) for spring and fall of 2014 and 2015. Treatments include three sequential transplanting dates that were 10 days apart starting from early April (2014 & 2015) or early September (2014) and mid-August (2015). Both cultivars were transplanted from seedlings raised in a greenhouse. Two rows of seedlings were planted in 30” wide black plastic mulched raised beds, with a row spacing of 12” and in-row spacing of 18”. Beds were irrigated with one drip tape (5/8”, 8 mil, 12” emitter spacing) that was buried in the middle of beds under the plastic mulch. The high tunnels were covered with single (Greensboro) or double-layer (Goldsboro) 6-mil polyethylene films. Temperature inside the high tunnel was managed at between 50 to 85 °F (optimal 68 to 85 °F) through opening/closing sidewalls and applying row covers, when temperatures inside the high tunnel went below 50°F. The experiment was conducted as a split-plot design with four replications and cultivars being main plots and planting dates as split plots. A total of 8 seedlings were planted in each split plot. Results indicated that early to mid-April planting dates seemed to work best for both zones in the spring. In both fall seasons, fruit was not able to reach mature color but mature green fruit stage was met. For single-bay high tunnel with two beds (four rows) of bell pepper, tomato, and cucumber, the estimated material cost was about $825 excluding infrastructure; labor cost was about $2,052 (with harvesting labor of $1,440); and the gross income was about $19,428. The estimated net income was $16,550.50 or $5.75/ft.²/season. Our research proved that Bell pepper could be a profitable crop for organic high tunnels in plant hardiness zones 7&8.

Aggregate Depth and Irrigation Frequency Affects ‘Rex’ Lettuce Development in a Shallow Aggregate Bed Hydroponic Production System

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A novel soilless technique for the production of lettuce was tested to determine the viability of ornamental greenhouse growers adapting their ebb-and-flood irrigation benching to diversify into salad greens without having to purchase the conventional NFT or DFT hydroponic systems. The independent variables that affected the growth of lettuce were aggregate depth and irrigation frequency. Therefore, the experimental design was a three by four factorial, with three treatments for depth (19 mm, 38 mm, 57 mm) and four treatments for irrigation frequency (once every 1 h, 2 h, 4 h, and 8 h), totaling twelve treatment combinations, each
replicated three times in a randomized complete-block treatment design. Seeds of ‘Rex’ lettuce were planted in phenolic foam cubes, and sixteen plants were transplanted into each shallow-aggregate ebb-and-flood (SAEF) systems upon the emergence of four true leaves on each seedling. Forty-two days later, shoot diameters and chlorophyll content were measured, and shoots were harvested, weighed fresh, and then dried to acquire their dry weights. The treatment with 38 mm of aggregate irrigated every 2 h produced significantly higher average fresh and dry shoot weights than all other treatments: 343 g and 13 g, respectively. The treatments with 19 mm and 57 mm of aggregate irrigated every 8 hours produced significantly lower average fresh and dry shoot weights and chlorophyll content than all other treatments as well as the lowest average shoot diameters. Chlorophyll content was significantly higher in the 57 mm treatment irrigated every 8 hours than in all other treatments, and the 19 mm treatments irrigated every 1 h and 2 h produced the lowest average chlorophyll content. Aggregate depth and irrigation frequency were demonstrated to significantly affect lettuce shoot diameter, chlorophyll content, as well as fresh and dry weight. The optimal treatment of 38 mm aggregate depth irrigated every 2 h proved the viability of the SAEF system and its potential to produce uniformly marketable lettuce shoots reliably.

First and Second Cut Kale Trials in Georgia
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Kale (Brassica oleracea L. Acephala group) has grown in popularity in recent years due perceived health benefits and changing consumer interests. For this reason, kale variety trials were conducted in Georgia in Fall 2015. In total 19 varieties were grown. This included curly, Tuscan, Siberian, and Portuguese kales. Varieties were harvested twice. Yields were highest in ‘Blue Scotch’, an open pollinated variety; however, they were not significantly different in five other varieties for the first harvest and seven others for the second harvest. There were no significant interactions between variety and harvest time; however, the variety Darkibor, while being the seventh highest yielding variety in the first harvest was the second highest yielding in the second harvest. The variety Tuscano was the highest yielding Tuscan type and was significantly greater than ‘Black Magic’. Two Portuguese kales were evaluated, ‘Bierra’ and ‘Marriot’; however, Marriot formed a head and was not harvested a second time. Overall this trial provides important variety information for Georgia growers.

Evaluation of Organic Cool Season Vegetable Rotations in Georgia
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Two cool-season rotations were conducted over three years to evaluate cool-season vegetables in rotation with various cover crops. Vidalions have become the single most important vegetable commodity produced organically in Georgia. The purpose of these rotations was to evaluate alternative high value cool-season vegetables that could be produced in rotation with onions. One rotation included only warm-season cover crops while the other included both warm-season and cool-season. Yields among the crops grown were mixed. Short-day onions consistently produced good yields compared to conventional onion production. Strawberries had decreasing yields over the course of the three years with no understanding why. Irish potato and broccoli yields increased each year of the experiment, but remained below average conventional yields for potatoes and equaled conventional production for broccoli in the final year. Lettuce yields were dramatically higher than Georgia yields, but were comparable with national averages. Carrot yields were less than half conventional production in all years. More work is needed in this area with longer-term experiments.

High Tunnel and Field Vegetable Cultivar Trial Updates from Mississippi
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In 2015, cultivar trials were conducted in central Mississippi on snap beans (Phaseolus vulgaris L.), cilantro, broccoli, Asian greens, carrots, and leaf lettuce. We report here on two of these trials, a fall snap bean trial and a spring carrot trial. We tested eleven snap bean cultivars in an on-farm trial at Bude for yield and suitability for farmers’ market and other direct sales outlets. The Valentino and Bronco cultivars were in the top statistical grouping for yield. Bronco produced straighter but lighter pods than Valentino and was selected by the grower-cooperator as the best bean in the trial. We tested seven carrot entries in a high tunnel trial, selecting smaller rooted entries suitable for our Loring silt loam, again with direct sales as the target market. Seeds were sown into rows 8 ft. (2.4 m) long, 1 ft. (0.3 m) apart, at 15 seeds/ft. There were no significant differences in total or marketable yield in this trial. However, the marketable roots of Yellow Sun, a yellow rooted cultivar, were significantly wider than those of all the other entries. We quantified incidence of defects in the culr roots and found that xx and xx had significantly more rotten roots than the other entries.

Tomato Responses to Broiler Litter Fertilizer
William B. Evans*
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Chicken (Gallus gallus domesticus) broiler litter pellets are being produced and marketed as fertilizer by several entities across the nation. We tested four combined rates of two litter-based fertilizers from on the growth, quality and yield of tomatoes...
Different among application rates in this study. The total amount of nutrient applied (N, P, K, Ca, Fe, and Zn) was reasonably good in the study but not significantly lower than the amount applied in the field. Leaf Mg, Mn, Cu, and B concentration at first fruit harvest increased with increasing litter rates. Leaf N, P, K, Ca, Fe, and Zn were not significantly affected by litter rate. There were no significant visual deficiency or toxicity symptoms seen in foliage. Fruit yield (marketable, cull, and total) was reasonably good in the study but not significantly different among application rates in this study.

Quantifying Nitrate Levels in Aquaponic Water and Lettuce (Lactuca sativa L.) Leaves Grown under Two Feeding Regimens

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An experiment was conducted in 2015 at two locations to track nitrate, pH, dissolved oxygen (DO), and electrical conductivity (EC) in an aquaponics system managed at two nutrient content in solution. One system was managed at high fish stocking density resulting in high nitrate content in the water. The other system was managed at a low fish stocking density. A multi-parameter probe was used to measure and record nitrate, pH, DO, and EC every 5 minutes for a 2-month period between August and September 2015. ‘Rex’ lettuce leaves were collected from both locations and sent for leaf nitrate tissue analysis. Probe readings indicated that the high fish stocking density had lower nitrate content (8.74 ppm nitrate) than that with low fish stocking density (12.16 ppm nitrate). EC readings were 884 µS/cm at the low stocking density and 376 µS/cm at the high stocking density. Temperature, pH and DO did not differ between the two locations. Leaf nitrate content followed a similar trend as EC with 5858 ppm and 4,481 ppm at the low and high stocking density, respectively. Initial results indicated a huge discrepancy between what the growers thought their nitrate content of the water was and what the probe measured. Our results also indicated that lettuce leaves have significant amount of nitrates in the tissue. Additional work is needed to confirm these initial results.

Comparison of Grafted versus Non-grafted Organic Watermelon Yield and Quality within an Enhanced Native Pollinator Habitat

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The aim of this research project was to modify traditional watermelon production habitat by inclusion of native wildflower species as an attractant for increased native pollinator bees and other pollinating insect species. With the increase in pollinator habitat, the likely hood there will be for better pollination of the fruit and overall increased yield and quality. In adverse weather conditions, honey bees typically do not leave the hives leaving a majority of the pollination duties left to the native pollinator species. However, inadequate native wildflower habitat that serves as an attractant and alternative nectar source when the watermelon flowers are closed often leads to a lack of successful watermelon pollination, thus loss in yield and quality specifically hollow-heart. A preliminary trial partially funded through the National Watermelon Promotion Board was conducted in 2015 at Clemson Coastal Research and Education Center. This preliminary work identified approximately 7 of 18 native wildflower species that attracted and served as an alternative nectar source for honey bee, native bee and other pollinating insect species. Of the 11 main genera of bee species visiting the watermelon and wildflowers, Halictid sp. were most numerous, followed by Apis mellifera, Megachile sp., and Bombus sp. Notably, all bee species preferred non-grafted compared to grafted watermelons except Bombus sp., which overwhelmingly preferred grafted watermelon by 62%. This study will be repeated again in 2016 by utilizing 7 of 18 native wildflower species that proved to be promising as alternative nectar sources along with multiple rootstock and scion material including seedless watermelons. In addition to bee visitation, yield and quality, grafted versus non-grafted watermelon flower volatile head space will be collected for analysis and flower colorimeter data will be collected to determine the effects of grafted watermelon transplants on bee attraction.

National Sweetpotato Collaborators Group

Sweetpotato Yields among Small Vegetable Farmers and Potential to Increase Production In Southeast Virginia

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Consumption of sweetpotato (Ipomoea batatas) has increased in the past decade in part due to its nutritional and health attributes, and to the availability and convenience of processed products. Virginia used to raise 15,000 to 19,000 acres of sweetpotato in the 1960s with a market value of $5 to 8 million for the state, but this market share was gradually lost in the 1970’s. With the expansion in sweetpotato production in the southeast, farmers in the coastal plains of Virginia and in the DelMarVa Peninsula have expressed their interest in growing sweetpotato and getting back their market share. This study investigated sweetpotato production in Virginia and the performance of recently released cultivars. A survey was conducted in 2015 including farmers from Virginia’s Eastern Shore, Northern Neck area, Virginia Beach Co., and Dinwiddie Co. Most field surveyed ranged...
between 2 and 4 acres except one organic field with 30 acres. Four 1-row plots 10-ft. long were randomly selected and hand harvested to determine yield. The cultivars grown by farmers included Covington, Beauregard, Bellevue, Burgundy, Diane, Evangeline, Bonita, and O’Henry. In addition, the NSCG cultivar trial was conducted at the Eastern Shore AREC, Virginia Tech. The local Hayman cultivar was included to compare with Bonita and O’Henry. Experimental design was a CRB with four replications and plots consisted of one 20-ft. long row planted at 12 x 36 inches. Marketable yield among all cultivars from surveyed commercial fields ranged from 340 bushel/acre to over 1100 bushel/acre. Irrigation appeared to be the main factor for the significant differences in yield. Marketable yield from the cultivar trial at the Eastern Shore AREC ranged between 532 and 956 bushel/acre. These yields are well within the yields obtained in the main sweetpotato production states and therefore it appears to be a good alternative crop for farmers in Virginia.

Comparison of Three Color Combinations of Light-emitting Diode, and Ambient Light Treatments for Sweetpotatoes Grown in Greenhouse Conditions

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Light-emitting diode (LED) technology is quickly becoming the dominant source of supplemental lighting in greenhouses. The recent work compares 3 color combinations of LED and ambient lighting for sweetpotatoes grown in greenhouse conditions during the off-season. The LED technology used allows the precise control of light color (red, white, and blue) and intensity. Specific color combinations can be adjusted to potentially optimize specific traits like plant height and growth rate. It has also been documented that LED technology provides increased energy savings relative to conventional lighting technologies. At Louisiana State University, the sweetpotato virus-tested foundation seed program routinely begins with in-vitro derived plants that are grown in greenhouses starting in winter months. During this period of short day lengths, light can be a limiting variable to growth and development. We will describe the use of commercially available LED lighting technology with adjustable light intensity and color ratio, and report on the performance of sweetpotato plants derived from in vitro cultures.

Crop Tolerance to Command Carryover in Sweetpotato (Ipomoea batatas)

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Over 20,000 acres of sweetpotatoes (Ipomoea batatas) are planted in Mississippi annually, but there are few herbicides labeled for use in sweetpotato. Command 3ME (clomazone) is a commonly used herbicide that is labeled in soybean, rice, tobacco and several vegetable crops. Residual effects of Command may persist more than one season. Research has been conducted to evaluate the potential carryover of Command applied post-transplant in sweetpotato to rotational crops such as corn (Zea mays L.). Studies were conducted at the Pontotoc Flat Ridge-Flatwoods Branch Experiment Station in Pontotoc, MS, Black Belt Experiment Station in Brooksville, MS, and the R.R. Foil Plant Science Research Center in Starkville, MS. Plots were arranged in a randomized complete-block design with four replications. Treatments included Command at 48, 24, 12, 6, 3, 1.5, and 0.75 oz/ac along with an untreated check. Command was applied pre-emergence to the rotational corn crop immediately after planting. Pontotoc plots were 10 x 30 ft. with four 30-in. rows. Starkville and Brooksville plots were 6.33 x 40 ft. with two 38- in. rows in 2014 and 2015. Corn injury decreased overtime at Pontotoc, while injury increased at Starkville and Brooksville. There was no difference in plant stand with Command rates less than 1X rate at all locations. Plant height decreased with 1X rate Command at 2 of 3 locations. Plant height was unaffected at rates less than 1/2 X. Corn yield was reduced with 1X rate Command at all locations and with the 1/2 X rate at 2 of 3 locations compared to the untreated check. Herbicide carryover depends on rate applied, soil texture, pH, rainfall amount, temperature, wintry conditions, etc. Upon emergence, corn may show white leaves after rainfall, and grow out of the discoloration without a yield reduction using Command at 12 oz/ac or less. Corn stand, height and yield are unaffected by Command when rates of 12 oz/ac or less were applied in the sweetpotato rotation to corn simulation study. Therefore, minimal risk to corn yield loss is expected with Command at 12 oz/ac when rotating from sweetpotato to corn. In the future, herbicides that are not presently labeled need to be screened to identify alternate weed control options for use in sweetpotato production.

Potyvirus Re-infection During Virus-tested Sweetpotato Seed Production in Louisiana

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Challenges remain for providing healthy sweetpotato plants at the farm level because of the very rapid rates of re-infection with the complex of potyviruses that contribute to cultivar decline. It is further complicated by the fact that most U.S. sweetpotato seed programs are conducted in geographic areas with long histories of sweetpotato production and with abundant populations of alternative hosts such as, morning glories. To address issues with virus re-infection at the LSU AgCenter Sweet Potato Research Station (SPRS), several strategies have been employed: production of research seed at an isolated off-site location, aggressive herbicidal control of morning glories focusing on perennials, and in 2014 and 2015 rogueing of selected seed production fields. Sample lots of seed roots have been indexed during the
winters of each year to determine incidences of re-infection. No virus re-infection was detected in seed produced for research at St. Joseph, LA during the 2012, 2013, or 2014 seasons. Ten of 18 seed lots from different fields and cultivars produced in 2013 had seed roots in which potyviruses were detected by indexing on the indicator host *Ipomoea setosa* with incidence ranging from 3% to 42% of roots. During 2014 seed fields were rogued from early June to late August and 24 plants with virus symptoms were removed. These plants were proximal to an infected plant of *Ipomoea x leucantha* growing prostrate in grass along a highway right of way. Three of 18 seed lots produced in 2014 included infected roots with incidence of 1% to 2% in each of those lots. No symptomatic plants were found during roguing of seed fields in 2015 and indexing of those roots is in progress. Studies of re-infection in research plots in Baton Rouge will also be discussed. In those plots, roots were indexed both by grafting to *I. setosa* and by multiplex PCR method of Li et al. (2012) and it appears that the PCR method was more reliable. While significant progress has been made in reducing rates of potyvirus re-infection at SPRS, it is difficult to pinpoint the contribution of different practices to that reduction or to determine how useful those practices will be at the next level of seed production on farm. Efforts are continuing to identify best management practices for producing virus-tested seed.

**Saponins in Sweetpotato Varieties Grown in North Carolina: An Exploratory Study**

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Saponins are known to have several biological effects such as anti-inflammatory, anti-microbial, anti-diabetic, cholesterol-lowering and antioxidant activities. With both hydrophobic and hydrophilic components in the molecule, saponins have been used as natural foaming agent and emulsifier in food, detergent and cosmetic products. However, limited information is available on saponin content in sweetpotatoes. This study was conducted to evaluate the saponin content in the leaves of several sweetpotato genotypes grown in NC. Sweetpotato leaves of five sweetpotato genotypes (Bonita, B9414 Beauregard, Covington, Kotobuki and NC413) were collected from the Horticultural Crops Research Station, Clinton, NC. Freeze-dried samples were macerated with 80% methanol and the supernatant was vacuum dried. The dried residue was blended with water, partitioned with n-butanol, methanol and acetone to obtain the crude saponin extracts. The residue was blended with water, partitioned with n-butanol, methanol and acetone to obtain the crude saponin extracts. Total saponin content was determined by spectrophotometric method and expressed as mg of oleanolic acid equivalents per gram powder. Saponin contents of 0.48-1.26 mg/g powder were found in leaves of the five varieties (Bonita > B9414 > Kotobuki > Covington > NC413). Saponin content of 2 mg/g dry weight was reported in root samples of a sweetpotato variety from Peru. Further studies need to be conducted to optimize extraction conditions and screen more sweetpotato varieties for high saponin contents.

**Developing Agronomic Best Practices for Sweetpotatoes under Canadian Growing Conditions**

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Sweetpotatoes have become a significant specialty crop for Ontario in recent years, with approximately 1300 acres in production. Ontario sweet potato yields are typically much lower than those from the southern United States, largely due to the shorter, cooler growing season. Growers have identified increasing yield as a high priority. Field trials were conducted in 2015 at a grower farm near Walsh ON and at the Simcoe Research Station near Simcoe ON to determine the effect of transplant size, irrigation and rates of P and K fertilizers on yield of sweet potato. Five transplant size categories, ranging from 7.5 to 20 cm long were evaluated. Yield was not significantly affected by transplant size, however there were consistent numerical trends of higher yields with increasing transplant size. The irrigation trial consisted of a non-irrigated control and an irrigated treatment with applications scheduled using evapotranspiration data. Only two irrigation events occurred, but irrigation still resulted in higher total yield. Trials evaluating various rates of phosphorous (0-125 kg/ha P₂O₅) and potassium (0-225 kg/ha K₂O) fertilizer were conducted in order to develop fertility recommendations for Ontario sweetpotato growers. Total and marketable yield, number of roots and weight per root increased with increasing rates of P₂O₅. Yield of No. 1 grade roots increased with increasing rate of K₂O. Results from a herbicide tolerance trial will also be presented.

**Development of Transgenic Sweetpotato With Multiple Virus Resistance In the United States**

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Sweetpotato (*Ipomoea batatas* (L.) Lam.; *Convolvulaceae*), a plant widely grown in all tropical and subtropical areas, is among the 10 most important food crops worldwide. As a crop produced by vegetative propagation, sweetpotato may accumulate pathogens, particularly viruses, in the planting stock. *Sweet potato feathery mottle virus* (SPFMV) and *Sweet potato leaf curl virus* (SPLCV) are two of the most prevalent sweetpotato viruses that cause devastating diseases and yield reduction in US. To date, immune resistance has not been identified in *Ipomoea batatas* and resistance to virus infections remains the most cost effective way of disease management. In this study, we will explore a novel biotechnological method to develop transgenic sweetpotato (cv. Beauregard) plants with resistance to these two viruses. We engineered part of coat protein (CP) gene of SPFMV and the replication origin region of SPLCV into a binary vector for
Agrobacterium-mediated genetic transformation for transgene expression. The SPFMV CP gene and SPLCV replication origin sequence are designed in antisense for the optimal induction of RNA silencing in transgenic sweetpotato. Our preliminary results showed that expression of foreign genes has been achieved by using Agrobacterium tumefaciens strain EHA105 harboring the expression cassette; similar results of transformation were observed when particle bombardment system of gene delivery was applied. Further investigation on transgenic plant regeneration and resistance to virus infection under control and field conditions will be conducted. Successful execution of this project will significantly boost quality of life and environment in the underserved communities and enhance research, education and extension capacities of Alcorn State University.

Developing Bacillus subtilis Probiotic Feed Supplement Feed Supplement from Sweetpotato–Soymeal Fermentation

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Human and animal health can be improved by incorporation of probiotics, which are live microorganisms that inhabit our gastrointestinal track and help in food absorption. Many Bacillus species bacteria are known to exhibit probiotic activity. Recent studies have indicated the probiotic activity of Bacillus subtilis in piglets to prevent diarrhea. Sweet potato is an important crop of southern United States and developing valued added products that cater to the animal health industry. The overall objective of the present study is to develop value added sweet potato- soymeal fermented probiotic enriched with Bacillus subtilis which can be potentially used as feed supplement in piglets to prevent diarrhea. Specific objectives of the study are: 1) develop optimal media composition that support maximum colony forming units (CFU), 2) Nutritional profiling of fermented and control samples. To achieve these objectives submerged fermentation using sweet potato soymeal were optimized using design of experiments (DOE). The best media composition was validated for CFU and fermented samples upon drying were subjected for nutritional profiling. The CFU for submerged fermentation was samples were 10^10 live spores per gram of dry samples. The presentation also discuss the method followed for the fermentation and nutritional profile of the control and fermented samples.

Influence of Growth Retardant and Cultivars on Secondary Metabolites Profile In Sweet Potato Grown Under Hydroponic System In Greenhouse Conditions

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Prohexadione-Ca, A structural mimics of 2-oxoglutaric acid, which is the co-substrate of dioxygenases that catalyze late steps of GA biosynthesis has been found to enhance storage root yield in sweetpotato. However, enzymes similar to the ones involved in GA are also important in the formation of other plant metabolite including flavonoids. Some of the secondary metabolites in sweetpotato which have gained importance in recent years are phenolic compounds, flavonoids, vitamin C and carotenoids. These metabolites are known to act like antioxidants and play a role in human health. Bioactive flavonoids signal to microbes, serve as allelochemicals and are important nutraceuticals in the animal diet. The overall goal of this study was to determine the effect of prohexadione-Ca on the biochemical composition of the storage roots and shoots of sweetpotato grown under greenhouse conditions using hydroponic system. Specific objectives were to: Determine the effect of pro-Ca on secondary metabolites in sweetpotato storage root and shoot; determine the effects of pro-Ca on sugars in sweetpotato storage roots; determine genotype x treatment interaction in the response of sweetpotato to pro-Ca. The study included one Alcorn State University breeding line and one cultivar (O’Henry). Plants were treated with prohexadione-Ca at the rate 0 and 810 mg a.i. L^-1 for control and treated plants, respectively. Both root and shoot (vine) samples were collected at 2, 4, 6, 8 and 10 week interval and subjected to biochemical characterization. Specifically, total phenolics, total flavonoids, Vitamin C, Sucrose, caffeic acid, chlorogenic acid, apigenin and kaempferol were analysed using HPCL and spectrophotometer. Impact of plant growth retardant and genotype on the profiled metabolites will be discussed.

Sweetpotato as a Feedstock for Bio-Oil Production Using Oleaginous Yeast Fermentation

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With the depletion in the global oil reserves and projected increase in demand along with concern over global warming search for alternative clean, sustainable and green fuels is underway. Department of Energy (DOE) and National renewable Energy Laboratory (NREL) consider biodiesel as one of the important solutions in developing clean burning biofuels. Biodiesel is a renewable, clean combusting, biodegradable fuel that can be produced from plant lipids, animal fat and microbial lipids. There is an increased interest in production of lipids from microbes specially yeast called oleaginous yeast due to the favorable spectrum of lipids for biodiesel and ease of production. For the large scale production of yeast lipids choice of cheap feedstock is very critical. Keeping the feedstock in mind sweet potato, an important crop of southern USA is being evaluated for oleaginous yeast Trichosporon oleaginosus fermentation. Response Surface Methodology (RSM) for process optimization, yield of lipid and spectrum of fatty acids and scale up strategies will be discusses.
Compositional Characteristics of Principal U.S. Sweetpotato Cultivars and Genotypes

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Sweetpotato root composition was determined in raw and baked roots of fourteen commercially important sweetpotato cultivars and/or breeding lines. Analyses of root tissues were made at harvest and after 2 and 9 months of storage at 14°C. The percentage of dry matter and crude starch content decreased in the sweetpotato roots during storage. The general pattern of change in the three principal individual sugars during long-term storage of the raw roots included an increase in the main disaccharide sugar sucrose, but a decrease the secondary monosaccharide sugars (glucose and fructose). After 9 months of storage, ‘Evangeline’ contained the highest amount of sucrose (8.11%), while the purple-flesh line ’13-164’ contained the lowest amount (1.63%). ‘Bayou Belle’ contained the highest amount of glucose (2.48%), while ‘Evangeline’ contained the lowest amount (0.73%). ‘Bayou Belle’ contained the highest amount of fructose (2.00%), while ‘Muraski’ contained the lowest amount (0.52%). The total sugar content in the baked roots of the majority of sweetpotato cultivars decreased slightly during the storage interval from 2 to 9 months. Baked roots of ‘Bonita’ contained the highest amount of total sugar (18.55%), while the ’05-24’ contained the lowest amount (11.83%) after 9 months of storage. The general pattern of change in the four principal individual sugars in baked roots during long-term storage included a decrease in the principal sugar maltose, but an increase in the secondary sugar sucrose. Baked roots of ‘Muraski’ contained the highest amount of maltose (12.19%), while ’05-24’ contained the lowest amount (2.42%). Baked roots of ‘Evangeline’ contained the highest amount of sucrose (9.51%), while ’13-164’ contained the lowest amount (1.76%). The baked roots of the breeding line ’05-24’ contained the highest amount of glucose (3.54%), while ‘Muraski’ contained the lowest amount (0.82%). ‘Bayou Belle’ contained the highest amount of fructose (2.27%), while ‘Muraski’ contained the lowest amount (0.54%). The crude protein content of the dry matter of the sweetpotato cultivars at harvest ranged from 8.62% in ‘Burgundy’ to 5.27% in ‘Bonita’. Potassium (K) was the principal macronutrient element in all cultivars and ranged from 1.53% in ‘Beauregard’ to 0.96% in ‘Bonita’.

Overview of Vineland’s Sweet Potato Breeding Program

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In 2014, Canada imported 45,000 tonnes of sweet potato from the USA with an estimated value of $37 million. Canadian production of sweet potato (Ipomoea batatas) is limited (approximately 1600 acres) compared to the USA, and therefore imports are required to meet consumer demand. Almost all sweet potato production in Canada occurs in Ontario and therefore an opportunity exists to expand production to other Canadian provinces. The main objectives of Vineland’s breeding program in 2015 were to i) evaluate five advanced numbered selections across Canada ii) evaluate sweet potato fries for sensory differences and drivers of consumer preference, and iii) sequence 47 lines using Genotype-by-Sequencing (GBS). Five sweet potato selections were evaluated using a randomized complete block design with four replications at grower locations in five Canadian provinces. All selections were compared to the commercial varieties Covington and Orleans. Each plot was evaluated for yield (No. 1s, canners, jumbos, and culls), skin colour, flesh colour, colour distribution, shape, and shape uniformity. The selections were also evaluated for dry matter, phenolics, and sugar content. Plant Breeders’ Rights were filed in Canada for two of the selections and are currently being virus-indexed at LSU. Nineteen sweet potato fry products (5 commercial varieties and 14 selections) were evaluated for sensory attributes using Vineland’s trained sensory panel. In addition, 209 consumers were used to evaluate nine of the sweet potato fry products on taste, flavor, and texture preference, and six of the products on visual preference. Consumer preferences were found but external preference mapping could not identify preference drivers (p=0.182). Preference could only be explained by visual appearance. Forty-seven sweet potato lines were sequenced on an Illumina HiSeq using two replicates per line. The sequencing produced 255,096,163 barcode filtered reads of which 244,046,665 mapped to the Ipomoea trifida genome. Approximately, 34,000 single nucleotide polymorphisms (SNPs) were identified among the population and are currently being virus-indexed at LSU. Nineteen sweet potato selections are evaluated using a randomized complete block design with the TASSEL-GBS v3 pipeline. A dendrogram was generated to illustrate the diversity that exists among commercial sweet potato varieties.

Effect of Microbial Formulation on Sweetpotato Growth and Yield, and Insect Damage to the Roots

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Sweetpotato variety ‘Beauregard’ was planted in replicated field plots each consisting of 4 rows and 50 ft long to evaluate the effect of a microbial formulation, SumaGrow (World Harvest Group) on root development, yield and insect damage. The two SumaGrow treatments were applied at 0.5 gal formulation per acre after 2 and 4 weeks of transplanting. Insect pest populations were monitored throughout the growing season with purple sheet traps coated with Tangle-Trap insect glue. Biweekly sweetpotato plant samples were taken from each experimental plot to evaluate vegetative growth and root development over growing season. Each sample consisted of 6 sweetpotato plants excavated in entirety. The root mass and size were recorded. The vine length and weight were also taken to evaluate vegetative growth. All experimental plots were harvested; roots graded and evaluated for insect damage and yield.
Sweetpotato Yield in Response to Timac Fertilization and Biostimulant on Covington Sweetpotatoes

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Many amendment and growth enhancement products are being sold to improve crop productivity. Two Timac Agro USA products (Duo Maxx and Fertiactyl GZ) were evaluated. Duo Maxx is a fertilizer additive that is claimed to reduce the leaching by slowing the release of nutrients and to enhance the uptake of nutrients in the rhizosphere. Fertiactyl GZ is characterized as a biostimulant that contains humic and fulvic acid, glycin, zeatin and some major and minor elements. It is soil applied and taken up by the roots, and is marketed as a product that will increase nutrient absorption, especially phosphorus and trace elements; increases root system size; and enhances photosynthesis. ‘Covington’ sweetpotato plants were established by a commercial grower on 5 June 2015. 300 lb/ac of 9-6-29 fertilizer was applied on 16 June, while 500 lb/ac of 11-0-29 was applied at layby on 1 July. Duo Maxx was used to amend the two fertilizers at 3 qt./ton. The biostimulant was applied at 3 pt/ac with a CO2 sprayer using 15 gal. water/ac on 18 June. There were a total of 6 treatments; two with no fertilizer applied, and four with fertilizer. The fertilizer treatments included; no amendment and no biostimulant; no amendment with a biostimulant; amended with Duo Maxx with no biostimulant; and amended with Duo Maxx plus the foliar application of the biostimulant. There were two treatments in which no fertilizer was applied; one treatment had no biostimulant applied, the other treatment had biostimulant applied. The experimental study was arranged in a randomized complete block design with four replications. Treatment effect was assessed by yields. Roots were harvested 20 October and graded according the USDA standards and weighed. All treatments in which fertilizer was applied out yielded those in which no fertilizer was applied for all marketable size grades and total marketable yields. When comparing the use of Duo Maxx and Fertiactyl GZ singly or in combination, yields of number one marketable yields. When comparing the uses of Duo Maxx and no fertilizer was applied for all marketable size grades and total marketable yields. Duo Maxx plus the foliar application of the biostimulant. There were two treatments in which no fertilizer was applied; one treatment had no biostimulant applied, the other treatment had biostimulant applied. The experimental study was arranged in a randomized complete block design with four replications. Treatment effect was assessed by yields. Roots were harvested 20 October and graded according the USDA standards and weighed. All treatments in which fertilizer was applied out yielded those in which no fertilizer was applied for all marketable size grades and total marketable yields. When comparing the uses of Duo Maxx and Fertiactyl GZ singly or in combination, yields of number one marketable yields. Results from monitoring studies and insecticide efficacy trials will be presented.

Insecticide Management of the Sugarcane Beetle and Other Soil Insects in Sweetpotato in Louisiana

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Soil insects can damage sweetpotato throughout the production cycle of the crop, including cucumber beetles (Diabrotica spp.) and the sugarcane beetle (Euetheola humilis Burmeister).

Cucumber beetles can cause damage throughout the production season, however, damage from the sugarcane beetle occurs late during the production season. Soil insect feeding damage compromises the aesthetic quality of sweetpotato roots, often leaving them unsuitable for market. Producers currently rely on traditional labeled soil insecticides and best management practices to manage soil insects in commercial fields. Sugarcane beetles were monitored at 2 locations throughout Louisiana in 2013-2015. Distinct peaks in activity were detected in May and September which concurs with historical data on this insect. Additionally, several insecticides currently labeled for use on sweetpotato in Louisiana were evaluated from 2013-2015 in field trials at several locations in Louisiana, for their efficacy against cucumber beetles and the sugarcane beetle. Soil insect damage was highly variable from year to year. Sugarcane beetle damage was extremely low in all years of testing. Results from monitoring studies and insecticide efficacy trials will be presented.

Root Knot Nematode (Rkn) Management in Sweetpotatoes With Nimitz and Dominus

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Preplant soil fumigation is in integral component of pest management for commercial sweetpotatoes in California. Soil fumigation is done both in the fall and spring to suppress mainly root knot nematodes, Meloidogyne incognita, and soil dwelling insects such as wireworms (Limonius spp) and grubs (Diabrotica spp, Phyllophaga spp). A new nematicide Nimitz (flusulfone) soon to be registered on sweetpotatoes also offers the potential of an alternative to fumigants. In 2014-15, fumigation trials were conducted in commercial sweetpotato fields to evaluate the efficacy of Dominus biofungidant (allyl isothiocyanate) as compared to standard Telone (1,3-D) treatments on yield and root quality. In 2015, additional trial work was conducted in Merced County and southern California to evaluate Nimitz nematicide efficacy. Treatment design for all trials was a randomized block with four replications. Fumigants and Nimitz applications were applied before transplanting and incorporated. Nematode samples were taken at both locations in early June to and again at the end of the season. Harvest was from the center bed of each plot and separated into standard #1, jumbo, and medium size categories. Regardless of treatment, location, or year, root knot nematode (RKN) counts in the spring and fall were highly variable. Only in one location in fall 2014 were RKN counts significantly reduced in the Telone treatment as compared to the other treatments. Plot yields were not correlated with fall RKN counts. Over two years, results with low rates of Dominus (10 gpa) or Dominus combinations were mixed, with significant yield increases compared to the untreated control in 2014 but not 2015, and with cull production significantly higher than Telone or metam in the Dominus treatments in both years. Dominus at 10 gpa increased total marketable yield 136% over the untreated control, while Telone at 12 gpa increased yield 157%. Much of the yield increase in total marketable yield occurred not only...
because of significant increases in #1 production but also as a result of dramatic increases in jumbo yield (>350%). Results with Nimitz nematicide were also mixed. Yield and quality were significantly increased with pre and post applications of Nimitz at in the southern California location, but there was no significant difference in a similar test conducted in a commercial field in Merced County.

Variation in Sweetpotato Root Architecture Response to Nematode Infection
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In sweetpotato, the successful emergence and development of lateral roots (LRs), the main determinant of root system architecture (RSA), determines the competency of adventitious roots to undergo storage root formation. Knowledge of the abiotic and biotic variables that control root architecture development can be integrated with other variables that are known to influence SR yields, enabling a more systematic approach to determining and managing yield constraints of this globally important food crop. In other systems, it has been demonstrated that nematodes, an important biotic constraint in sweetpotato production, profoundly influenced RSA, wherein infested roots were more branched or showed enhanced root growth compared to healthy root systems. The current study investigated the effect of three levels of RKN inoculum (0, 500 [low], and 5,000 [high] eggs/pot of race 3 of Meloidogyne incognita produced on Yolo Wonder pepper) on some RSA attributes in Beauregard and Bayou Belle, sweetpotato varieties which are highly susceptible and highly resistant, respectively, to this nematode population. The plants were harvested at 20 days and images of roots were acquired using a specialized dual optimal scanner followed by image analysis using WinRHIZO Pro. Beauregard consistently showed increased number of galls on LRs for both the low (100%) and high (1,396%) inoculum levels, confirming its relative susceptibility to RKN compared to Bayou Belle. Across varieties, there was a trend for increased LR number and length. Bayou Belle had increased LR length relative to Beauregard at low (164%) and high (51%) inoculum levels. These findings are consistent with some data in other systems wherein nematode infection is associated with root proliferation. These data can be used to further understand the plant’s response to nematode infection and can lead the consideration of root traits in selection strategies.

Lost In Translation? Exploring the Presumptive Association Between Arbuscular Mycorrhiza-Phosphorus Interaction and Some Root Rotting Pathogens
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Abuscular mycorrhiza (AM) has been referred to as the mother of plant root endosymbioses. AM, a symbiosis between plants and an ancient fungal phylum, improves the supply of water and nutrients, such as phosphorus (P) and nitrogen (N), to the host plant. In return, up to 20% of plant-fixed carbon is transferred to the fungus. AM activity has the potential to explain the generally accepted notion that sweetpotatoes require relatively low N and P inputs relative to other crop plants. In model systems and in some crop plants, it has been shown that AM increases plant resistance to some root rotting pathogens. Translational research that elucidates the presumptive relationship between AM-P activity on one hand, and incidence of root rotting, on the other, has the potential to help clarify the effects of some pre-harvest management variables on postharvest loss in sweetpotato. This presentation reviews some key findings in model systems as well as past seminal work on AM activity in sweetpotato in general and the relationship between AM and P activity in particular. Preliminary evidence on the possible link between P fertilizer treatments and postharvest loss will be presented. Preliminary observations and findings as regards methods and approaches in detecting and measuring AM activity in some sweetpotato varieties will also be discussed.

Current Status and Future Direction of Sweetpotato Research at the United States Vegetable Laboratory
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Sweetpotato (Ipomoea batatas L.) is one of the world’s most important root crops and is grown in more than 100 countries worldwide. It is an important specialty crop in the U.S. Since 1939, there has been continuous research on sweetpotato at the USDA, and for over 40 years at the U.S. Vegetable Laboratory (USVL) at Charleston, SC. Most of the research efforts have focused on combining multiple disease and insect resistance with improved yield and food quality and understanding the genetic basis of these traits. USDA researchers have been very productive with regard to developing improved sweetpotato germplasm, with over 20 cultivars and numerous seedling selections that have been incorporated in breeding programs at Louisiana State University and North Carolina State University. Future sweetpotato research at USVL will focus on the development of sustainable pest management options for sweetpotato production systems. Biologically-based management tactics will be developed against major insect and weed pests of sweetpotato crops. One primary approach will be the development of plant resistance factors that can be incorporated into advanced breeding lines and new sweetpotato germplasm. Knowledge will be obtained on the influence of climate change on pest and beneficial insects in sweetpotato crops. Biорational approaches will be developed for the management of a complex of soil-borne pests and sweetpotato whitefly. Whitefly:host-plant:virus relationships will be elucidated and a method of protection from whitefly-
vectored viruses will be developed. This research will lead to the development of pest-resistant genotypes that have improved yields and quality, as well as improved tools for managing insect pests, associated viruses, and weeds in sweetpotato crops. There has been a long history of collaborative sweetpotato research between USVL and other institutions; continuing this collaboration will be fruitful in addressing the problems facing producers of this important specialty crop.

**Update on the Genomic Tools for Sweetpotato Improvement Project**

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Sweetpotato is a widely recognized food security crop, grown predominantly in small plots by poor women farmers across sub-Saharan Africa (SSA). It is a priority crop for The Bill & Melinda Gates Foundation because it is a critical food security crop for millions of small farmers and it generates larger amounts of food per unit time compared to other major staples. Orange-fleshed types are an excellent source of β-carotene and they have been successfully deployed to address vitamin A deficiency in the region. However, the full potential of sweetpotato has yet to be recognized as large yield gaps (ca. 20 MT/ha) exist across rain-fed SSA due to a wide range of biotic and abiotic constraints. The GTSP1 project is focused on developing the core resources needed to bring sweetpotato breeding into the genomics era and make marker-assisted breeding (MAB) in sweetpotato more feasible. Specific project objectives include: (i) genome sequencing of two inbred diploid lines for use as a cultivated sweetpotato, *I. batatas*, reference genome; (ii) development of a genotyping by sequencing (GBS) platform, with supporting bioinformatics, quantitative genetic methods and analytical environments to facilitate quantitative trait loci (QTL) identification and genome wide association (GWAS) analyses; (iii) multi-location phenotyping and marker-trait/validation studies in the USA, Peru, Ghana and Uganda; (iv) traditional and web-based training and capacity development efforts to incorporate MAB tools in sweetpotato breeding programs in SSA. Our project is focused on developing marker-assisted breeding tools and genomic resources for the sweetpotato scientific community, and intellectual and institutional capacity required to facilitate crop improvement, setting the stage for increased rates of genetic gain for key traits (e.g., yield, resistance to sweetpotato virus disease (SPVD), combined high storage root β-carotene and dry matter content), drought and heat tolerance and decreased time required to release improved varieties to farmers in SSA.

**Watermelon Research & Development Group**

**Seedless Watermelon Variety Trials Conducted by University of Delaware Cooperative Extension 2015**

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In 2015, seedless watermelon trials were conducted by the University of Delaware at the Carvel Research and Education Center. There were 38 entries. Plants were transplanted to the field on May 19, 2015. Field plots were one row (2.13 m wide) and 9.14 m long. Plots were arranged in a randomized complete block design with three replications. In-row spacing was 0.91 m with 10 plants per plot. Two plants of the in-row pollinator variety ‘Accomplice’ and two plants of the in-row pollinator ‘Sp-6’ were planted in each plot. Fruits were harvested on July 24 and 28 and on August 6, 10, 12, and 24. Individual fruit weights were recorded and a subsample was evaluated for soluble solids, hollow heart, and hard seed. Yields in the trial were high and fruit were larger than usual. The highest yielding varieties in the trial in terms of marketable yield were: Exclamation (120,710 kg•ha⁻¹), SV7112WA, Charismatic, Joy Ride, Maxima, Razorback, WDL0409, SV0241WA, Sugar Fresh, Unbridled, KB12142, Secretariat, SV0258WA, Wolverine, Premont, Talca, Fascination, Cut Above, Captivation and Road Trip (93,372 kg•ha⁻¹). ‘Exclamation’ and ‘SV 0258WA’ had the largest average fruit size. ‘Troubadour’, ‘Traveler’ and ‘KB12023’ produced the highest percentage of melons in the 60 count class; ‘SV0241WA’ produced the highest yield of melons in the 60 count class. ‘Secretariat’ and ‘Cut Above’ produced the highest percentages of melons in the 45 count class (46.5 and 46.1%, respectively); ‘Secretariat’ also produced the highest yield of melons in this class. ‘SS7197’ produced the highest percentage of melons in the 36 count class; ‘Maxima’, ‘Sugar Fresh’, and ‘Embasy’ produced the highest yield of melons in this class. Exclamation and SV0258WA produced the highest percentage of melons in the 30 count class and Exclamation also produced the highest yield of melons in this class.

**Seedless Watermelon (Citrullus lanatus) Variety Trial for Kentucky, 2015**

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In Kentucky, watermelon (*Citrullus lanatus* L.) continues to be one of the primary vegetable crops. In acreage, it is only second to sweetcorn in the state and continues to grow. From 2007 to 2012 acreage planted increased by 40%. Additionally there is
potential for continued growth, particularly in the western part of Kentucky. Watermelons are grown in over 20 counties in various areas across the state with larger plantings occurring in Casey, Lincoln, Hart, Allen, Scott, Barren, Christian, Todd, and Daviess counties. In 2015, twenty seedless watermelon varieties were evaluated for yield and internal quality. The trial was established on 27 May 2015 when watermelon varieties were planted in the designated plots based on a randomized complete-block design with three replications. As in the last few year’s trials, Accomplice was utilized as the non-harvestable pollenizer for this trial. Each plot consisted of ten seedless watermelon plants in addition to five pollenizers. Pollenizers were interplanted between every pair of seedless watermelon plants within the row. Prior to transplanting, the field was prepared by tillage and bed formation using a plasticulture system. Experimental plots were 40 ft in length. Rows were spaced on 8 ft. centers with 4 ft. in-row spacing. Urea and muriate of potash were applied pre-plant at 110 lbs. and 100 lbs. per acre respectively. Calcium nitrate was applied weekly from 3 June to 31 July at a rate of 5 lbs. of nitrogen per acre via the drip irrigation system. Due to excessively wet soil conditions from all the precipitation, we fell short of the recommended nitrogen rate by 20 lbs. of nitrogen. Yields in 2015 were significantly lower than the previous season, ranging from 20,700 to 40,500 lbs. per acre. Numerically SV0258WA had the highest yield (297 lbs/plot) was only statistically greater than six of twenty varieties. Varieties that produced the majority of their fruit in the 45-count size class included SV0258WA, Lucille, Fascination, Talca, and Maxima. SV7018WA had higher brix (10.9%) than all other varieties. Varieties in the trial that performed well for both yield and higher Brix included Fascination, Lucille, SV7018WA, SV0258WA, and Unbridled.

Georgia Watermelon Variety Trial Results for 2015

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Georgia is a significant watermelon (Citrullus lanatus) producing state with nearly 20,000 acres grown annually. For this reason variety trials for seedless melons are conducted annually. In 2015, 32 varieties of seedless watermelons were grown representing nine companies. Fruit were harvested three times, weighed individually, and grouped according to class. The highest yielding variety was Summer Breeze though it was not statistically different from 25 other varieties. The lowest yielding entry was grafted melons of the variety Fascination. The highest average fruit weight was in the variety SV7112, which weighed 19.1 pounds. The lowest fruit weight was in the variety ‘Troubadour’. Total soluble solids ranged from 12.6% to 10.7%. Flesh firmness ranged from 4.6 pounds to 1.9 pounds when measured with a hand-held penetrometer. Hollow heart incidence was also measured; however, few melons exhibited symptoms of hollow heart. Overall results from this trial will be used to make recommendations for growers in Georgia.

Watermelon Cultivar Yield and Quality Trial Results, North Carolina, 2015

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Thirty five standard size triploid cultivars obtained from twelve seed companies were evaluated in 2015 at the Central Crops Research Station, Clayton, North Carolina for yield and quality. A grafted ‘Fascination’ plant to an interspecific squash hybrid TZ148 rootstock was also included in the study. The field study was a randomized complete design with four replications per treatment. Seeding was 15 April, while transplanting in the field was 20 May, 2015. Watermelons were grown on black polyethylene mulch with drip irrigation. Transplants were set in-row 2.5 ft apart while row centers were 10 ft, and three ‘SP-6’ pollenizer plants were equidistantly established per plot. Six harvests were made 16, 23 and 30 July; 6 and 26 August; and 9 September. Fruits were considered marketable when they were at least 9 pounds. Growing conditions were generally favorable during the crop season, the exception was for two weeks in June during fruit set as very high temperatures were experienced. Average fruit set of marketable fruit ranged from 1.9 to 4.0 fruits per plant over six harvests across all cultivars. Fusarium wilt, race 2 was confirmed and distributed across the field, and played a significant role in affecting cultivar yields. The fungicide Proline was applied 16 and 24 of July to help control the disease. Even with fusarium wilt pressure, over 90% of the foliage was present in ‘Crunchy Red’, ‘UG 131712’, ‘Fascination’ (grafted or non-grafted), ‘Premont’, and ‘Traveler’, while 80% of foliage was present for ‘Troubadour’, ‘Melody’, ‘Super Seedless 7167’, ‘Embassy’, and ‘USA W90020’. Some of the cultivars or advanced lines with the greatest foliage loss to fusarium wilt were; ‘Warrior’ (59%), ‘SV 0241 (58%)’, ‘Sweet Polly’ (55%), ‘Talca’ (53%), ‘SV 2757 (49%)’, ‘Maxima’ (46%), SV 7018 (45%) and ‘SV 8298’ (40%). Cultivars producing the largest fruit which averaged greater than 14 lb were Crunchy Red, Fascination (grafted and non-grafted), Super Seedless 7167, and Premont, while the smallest sized fruits (less than 11.5 lb) were produced by Secretariat, Troubadour, KB 12142, and SV 0241. The average total yields for all six harvest across cultivars was about 3700 fruit per acre. The highest yielding cultivars, which exceeded 4600 fruit per acre or 70,000 lb per acre were; Traveler, Crunchy Red, Premont, Troubadour, and Super Seedless 7167. The lowest yielding cultivars were Talca, SV 2757, SV 0241, and Maxima, which produced 2919, 2701, 2265 and 1830 marketable fruit per acre, respectively. Yields for grafted versus non-grafted ‘Fascination’ were similar. The lower yielding cultivars were greatly impacted by foliage and vine loss due to fusarium wilt.

Early Watermelon Fruit Development and Hollow Heart in Triploid Watermelon

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Results: North Carolina, 2015


S37
Past research at the University of Delaware showed that hollow heart disorder in triploid seedless watermelon was more severe in pollen limiting environments, incidence was higher with increasing distance from a pollen source, and that varieties differed in susceptibility to hollow heart with higher flesh density varieties having less hollow heart. In 2015 a study was designed with the diploid pollinizer variety Stargaze’ planted between plants of a higher flesh density triploid watermelon ‘9651HQ’, a lower density flesh watermelon ‘Liberty’, a small fruited variety Ladybelle and a long fruited variety Revolution in 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, 1:10, 1:11, and 1:12 pollinizer to seedless ratios progressively in the row. There was a linear relationship between hollow heart severity ratings and pollinizer ratio ($P < 0.0001$). In ‘Ladybelle’, hollow heart was not found until a ratio of 1:6 and then was found at low to moderate levels through the 1:12 ratio (increase from 1% to 23% hollow heart). Hollow heart was more severe in the triploid ‘Liberty’: at a 1:3 ratio there was 19% hollow heart while at a 1:12 ratio hollow heart incidence increased to 42%. The long fruited triploid ‘Revolution’ showed significant susceptibility to hollow heart when pollen was limited (9% hollow heart at a 1:3 ratio increasing to 63% hollow heart at a 1:6 ratio). A second study under differing pollen limitations was used to evaluate cell numbers in young watermelon fruit 1 to 8 days after pollination. Preliminary results showed that young fruit had fewer cells when pollen was more limited. These studies further confirmed that limiting pollen increases the incidence and severity of hollow heart and indicated that reduced access to pollen could impact cell numbers in developing fruit.

**Watermelon Yield and Fruit Size Response to Grafted versus Non-Grafted Transplants in Plasticulture and Bare Ground Production Systems**

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Some reported benefits using grafted watermelon plants are soil borne disease resistance, improved plant vigor, better nutrient efficiency, opportunities for organic production, better cold tolerance, and improved yields. These two studies were conducted to compare yields and fruit size from grafted versus non-grafted plants in a plasticulture and a bare ground production system. The tests were conducted on commercial farms in Pikesville and Seven Springs, North Carolina in 2015. The two treatments were ‘Fascination’ non-grafted plants and ‘Fascination’ grafted plants on interspecific squash hybrid TZ-148 rootstock. Transplants were established near 20 May. There were 3 plots of each treatment (grafted, non-grafted watermelon plants) at each location. A plot contained 20 triploid plants for each of the two study locations. For the study conducted with black plastic and drip irrigation, row centers were 10 ft and hills were spaced 2.1 ft apart in-row. For the bare ground study, row centers were spaced 3.3 ft with two rows planted, then two rows skipped. In-row spacing was 4 ft. The pollenizer used was SP-6. There were five harvests which corresponded with commercial harvests starting 20 July and concluding 1 September. In the plasticulture production system, more large fruit were produced from grafted versus non-grafted plants, which resulted in nearly 20% more marketable yield. Fruit size from grafted plants was 2.6 lb heavier than fruit from non-grafted plants. When grown in the bare ground production system, more 60 count fruit per bin (9.0 to 13.6 lb) were produced from non-grafted plants than grafted plants. A 107% increase in fruits that were greater than 17.6 lb (30 and 36 count fruit per bin) were obtained with grafted than non-grafted plants. Total and marketable yields were similar for grafted and non-grafted plants in the plasticulture production system, but more 60 count fruit per bin (9.0 to 13.6 lb) were produced from grafted plants than the plasticulture production system, but not the bare ground system, even though fruit numbers across size grades were similar. However, in the bare ground system, fruit numbers were greater using non-grafted plants than grafted plants. Fruits were generally 2.5 lb heavier from grafted than non-grafted plants. Watermelon fields in this study did not have fusarium wilt. Further studies to determine yields and fruit size from grafted versus non-grafted watermelon plants is needed in different environments and growing systems, and with various combinations of rootstocks and scions.

**Screening Potential Cucurbit Rootstocks for Resistance to Southern Root-knot Nematode (Meloidogyne incognita) and Reniform Nematode (Rotylenchulus reniformis)**

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Fusarium wilt (caused by the fungus Fusarium oxysporum f.sp. niveum) has been a worldwide problem in the production of cucurbit species such as watermelon. One method for combating this pathogen in the field is to graft a susceptible, high yielding scion on to a Fusarium wilt resistant rootstock. A concerning issue with rootstocks resistant to Fusarium wilt is that these rootstocks have not been tested for their susceptibility to root-knot nematode infection, more specifically the southern root-knot nematode (Meloidogyne incognita). Preliminary findings have demonstrated many Fusarium resistant rootstocks to be highly susceptible to root-knot nematode. Research was conducted during the spring and fall of 2015 to evaluate the resistance to root-knot nematode in rootstocks with known resistance to Fusarium wilt. Seven rootstocks were evaluated in the spring and six in the fall. A highly susceptible interspecific (Cucurbita maxima x C. moschata) rootstock (‘Carnivor’) was included as a positive control in both seasons. Root gall index (RGI) was evaluated at 60 days after planting (DAP) in the spring and 60 and 90 DAP in the fall. Additionally in the fall,
soil samples were collected at 60 and 90 DAP as well as root samples at 90 DAP to determine nematode populations in and around experimental rootstocks. Results showed that several *Citrullus lanatus* var *citroides* rootstocks (USVL 246, USVL 252, USVL 360) being developed by USDA-ARS Vegetable Lab exhibited significantly less root galling compared to the susceptible control. These rootstocks also had less *M. incognita* per gram of root. These findings indicate that rootstocks may soon be available to manage both Fusarium wilt of watermelon and root-knot nematode in grafted cucurbits.

### Managing Plant Pathogenic Nematodes with Novel Non-Fumigant Nematicides

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Many vegetable production areas of the U.S. are located on sandy, well-drained soils. These soil types offer many benefits to cultivation but are often infested with plant pathogenic nematodes. Root-knot nematodes (*Meloidogyne* spp.) being some of the most widely distributed and problematic. Many producers have traditionally managed plant pathogenic nematodes with fumigant nematicides. The use of soil fumigants has come under increased scrutiny recently and some producers are seeking alternatives to nematode management with soil fumigants. Unfortunately there are few non-fumigant nematicides available for vegetable production. Fluensulfone has recently been labeled for use in several vegetable crops and floupyram/has been labeled in certain agronomic crops and may potentially gain vegetable labels. These two products were compared with an industry standard, oxamyl, for their potential to manage Root-knot nematodes. A highly susceptible interspecific (*Cucurbita maxima* x *C. moschata*) squash, “Carnivor”, was used as a model crop. Treatments included fluensulfone pre-plant incorporated, floupyram drip applied at planting, floupyram drip applied at planting followed by oxamyl, oxamyl drip applied at planting followed by oxamyl, and a non-treated control. Roots were excavated and 60 and 90 days after planting and rated for root galling. At 60 days after planting fluensulfone and floupyram treatments significantly reduced root galling compared to the non-treated control but had significantly more root galling compared to treatments containing oxamyl. At 90 days after planting fluensulfone treatment did not significantly reduce root galling compared to the non-treated control. Treatments containing oxamyl had significantly less galling than fluensulfone or floupyram. This research indicates that oxamyl protects roots from root-knot nematodes better than fluensulfone and floupyram alone.

### Influence of Pollenizer Variety on Seedless Watermelon Production and Anthracnose Severity

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Anthracnose of watermelon is perhaps the most important foliar disease of watermelon in the US. Symptoms of this disease include irregular necrotic lesions on leaves, spindle shaped lesions on stems and sunken lesions on fruit. Yield reductions can result directly from fruit with anthracnose lesions or indirectly from foliage loss. Host resistance represents perhaps the most efficient method of anthracnose control. While there is no useful resistance in seedless watermelon hybrids, diploid varieties that are used solely to produce pollen for seedless watermelon vary significantly in anthracnose reactions. In two years of field trials, Saha and Egel showed that 15 varieties of watermelon used commonly for pollination purposes range from almost completely resistant to very susceptible. Four pollenizer varieties were evaluated for their impact on anthracnose on seedless watermelon yield in a split plot design with inoculated and uninoculated treatments in Lexington, KY, and Vincennes, IN. Each plot was 48 feet long and consisted of 12 seedless and 6 of one of the pollenizer varieties. Seedless watermelon were grown 4 feet apart within rows with a Pollenizer spaced 2 feet apart between pairs of seedless watermelon plants. The experiment was established at both facilities on 21 May. Disease severity ratings were collected on each treatment using the Horsfall-Barratt rating scale approximately weekly. Fruit were harvested for yields on 29 July, 7 and 18 August in Vincennes, and on 3, 10, and 17 August in Lexington. Although the trial consisted of inoculated and non-inoculated plots, symptoms of anthracnose could be found across all plots, regardless of inoculation status. Except for the first rating period in Vincennes on 14 July (data not shown), there were no differences noted in the amount of disease in the inoculated versus non-inoculated plots. This may have been due to the exceptionally rainy weather that was very conducive for anthracnose. There were no significant differences in anthracnose severity across varieties in either locations, masking both inoculation status and variety treatments. There were no differences in yield in number or weight per acre regardless of variety of pollenizer used in the treatment plots. This lack of difference in yield corresponds to the lack of difference in disease severity.

### How Does Planting Date Impact Stand Loss from Fusarium Wilt in Watermelon

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Fusarium wilt (*Fusarium oxysporum f. sp. niveum*) (FON) is a devastating soil-borne pathogen of watermelon. While resistance to race 1 of this pathogen exists there is no current resistance for races 2 or 3 in seedless watermelon. Disease incidence is generally greatest at soil temperatures below 27 °C. To determine if planting date and therefore soil temperatures could impact disease...
incidence of FON, three varieties of seedless watermelon were grown in Georgia and South Carolina on black plastic mulch and bare ground at three planting dates. Results suggested that soil temperatures were too low to inhibit FON incidence in the first two planting dates (20 Mar. and 10 Apr.); however soil temperatures had warmed considerably by the third planting date (30 Apr.) to inhibit FON incidence. More 70% of plants displayed symptoms of FON in both growing locations when planted on 20 Mar. or 10 Apr. However, 7% and 21% of plants displayed symptoms of FON in Georgia and South Carolina, respectively when planted on 30 April. This suggests that planting date can be used to manipulate the severity of FON in watermelon fields.

Evaluation of Fungicides for Management of Fusarium Wilt of Watermelon

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Fusarium wilt of watermelon, caused by Fusarium oxysporum f. sp. niveum, is an economically important disease in the United States and the world. Current management of this disease relies on crop rotation and host resistance, but the emergence of new races of the pathogen has cut down on the number of tolerant cultivars available to growers. Although currently limited in practice, chemical management of Fusarium wilt of watermelon could be an important facet of integrated disease control. This study examines the efficacy of new and existing fungicides in reducing Fusarium wilt of watermelon in the lab and in the field. Fungicide efficacy was evaluated in vitro using a fungicide amended media assay and in vivo in a small plot field trial conducted over Summer 2015. 10 single active ingredient fungicides were evaluated in an in vitro test across 4 concentrations. Among the best performing fungicides were prothioconazole and an experimental fungicide. Sensitivity to these two fungicides was measured across 92 isolates of Fusarium oxysporum, and no isolates were found that were insensitive to either of these fungicides. Field-testing these two fungicides at two concentrations and application methods indicated that both products significantly reduced disease, but a drench treatment followed by a foliar spray was superior in reducing Fusarium wilt incidence in comparison to either product used in only a drench treatment. These two fungicides could effectively complement existing strategies in Fusarium wilt management.

Poster Section

Current Season Trapping Results for SWD (Drosophila suzukii) in Central Alabama

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Spotted wing drosophilae (SWD) (Drosophila suzukii), is a fruit pest relatively new to North America. It was first reported in 2008 in central coastal California on maturing fruits of raspberries and strawberries. On June 28, 2011, SWD was first found on yellow sticky traps in Coosa County, Alabama. At the end of 2013, SWD was confirmed in 6 additional counties. The spread of this invasive pest continued and was confirmed in 15 Alabama counties by 2015. Spotted wing drosophilae attack soft skinned fruit including blackberry, raspberry, strawberry, and blueberry. Both larvae and adult are known to cause damage. Monitoring for SWD is suggested to farmers as a critical tool to establish presence of SWD in their location and implement an appropriate management strategy. Commercially available traps were used to monitor the SWD emergence and compare population development under managed and unmanaged blackberry production systems. Traps were deployed on May 19,2015 and the number of SWD caught was recorded weekly until end of July. Our results revealed a relatively low population numbers by the end of June, followed by a sharp increase by the end of July. Total number of SWD adults captured at a managed field increased gradually throughout the season, while at unmanaged fields the increase was exponential. Approximately twice as many female flies were captured throughout the season than were male SWD adults in both production systems. Monitoring for the presence of the pest and implementing a control strategy can help manage SWD populations and reduce the crop damage.

In Vitro Shoot Regeneration of Black Cohosh

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Black cohosh (Actaea racemose) was identified as one of the fastest growing herbal products. Supplies of black cohosh rhizomes, either for sale as raw medicinal materials or as “seeds” for production, come mostly from the large, easily harvested wild populations that have been exhausted. Production with true black cohosh seeds is unreliable because the seeds must be stratified and usually germinate over a period of two years after sowing. The objective of this study was to develop an efficient protocol for micropropagation of black cohosh. Young leaves of black cohosh collected from stock plants grown under sixty percent shade in a campus greenhouse were surface disinfested by soaking the whole leaves in a 15% bleach solution plus a few drops Tween-20 per liter for 20 minutes, followed immediately by three rinses using sterile distilled water. The surface-sterilized leaves were cultured on Murashige and Skoog (1962) base medium with supplements of 3% of sucrose and 0.7% agar, plus TDZ, BA, kinetin, IBA, and NAA at various concentrations and combinations under two levels of light conditions. Medium pH was adjusted to 5.6 with 1N KOH or 1 N HCl before adding agar. The culture medium was sterilized by autoclaving at 121 °C (106 kPa) for 20 minutes. After the initial light treatments, the cultures were placed in a plant tissue culture grade growth chamber at 23°C and under 16 hours of light per day provided by cool white fluorescent tubes. Cultures
were transferred onto the same fresh media every four weeks. Clusters of plantlets of black cohosh were produced in vitro from the treatments including TDZ, BA and kinetin. The clusters of young plantlets were then rooted in vitro in a rooting medium containing Murashige and Skoog basal salts plus IBA or NAA. Of which the IBA treatments produced better rooting. Rooted plantlets were subsequently acclimatized and vigorously grow in the same greenhouse under the same shade condition where the stock plants were raised.

**Kenaf’s Allelopathic Impact on Seedling Growth**

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Allelopathy is the chemical interaction between plants, which may result in the inhibition of plant growth and development. Research was conducted to determine the impact of kenaf (*Hibiscus cannabinus L.*) plant extracts on the post-germination growth of five plant species. Four concentrations (0, 16.7, 33.3, and 66.7 g/L) of kenaf bark, core, and leaf extracts were applied to the germinated seeds of cucumber (*Cucumis sativus* L.), Italian ryegrass (*Lolium multiflorum* Lam.), redroot pigweed (*Amaranthus retroflexus* Lam.), and tomato (*Solanum lycopersicum* Mill.). The developing seedlings were measured 7 days after application to determine the length of their hypocotyls (mm) and radicles (mm), and the number of hair roots. Tomato, Italian ryegrass, and redroot pigweed followed similar negative responses to the extract source (kenaf bark, core, and leaves) and the impact of extract concentration, whereas, cucumber had a mixed response and green bean reacted positively to the kenaf extracts. Of the species tested, tomato was the most sensitive across all kenaf extracts and concentrations, resulting in decreased hypocotyl, radicle, and root growth. Green bean exhibited no negative effects Kenaf extracts produced no negative effects on green bean, but actually produced increased hypocotyl growth independent of the source of kenaf extract. Kenaf extracts resulted in a mixed response for cucumber. The kenaf bark and leaf extract decreased cucumber radicle growth, whereas the bark and core extracts increased hypocotyl growth. Italian ryegrass hypocotyl growth decreased across all extract sources (bark, core, and leaf), while the kenaf leaf extract also reduced root growth. All kenaf extracts reduced redroot pigweed radicle growth, while the core and leaf extracts reduced hypocotyl growth. The research demonstrated that kenaf leaf extracts were the most allelopathic and hypocotyls were the most sensitive. Future research should isolate the chemicals responsible for both the negative and positive allelopathic impact on additional plant species, determine if the extracts will influence older plants, and pursue the use of these natural allelopathic extracts to benefit crop production and limit weed competition.

**Plant Selections for Vegetative Buffers: Can Phytopathogens be Effectively Remediated from Irrigation Runoff Water?**

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Increased competition for freshwater resources, negative environmental impacts associated with non-treated agricultural and horticultural production runoff, and increased regulations concerning water use and disposal, among other factors, have provided growers with significant incentives to develop onsite water treatment to enable water reuse and offsite release. Effective and low-cost water remediation technologies are necessary to ensure that irrigation wastewater contaminants (e.g. phytopathogens, pesticides, or mineral nutrients) are not reintroduced to crops irrigated with recycled water. Vegetative buffers have been shown to effectively remediate pesticides and mineral nutrients, but their capacity to remediate phytopathogens has not been characterized. The major objectives of this research project are: 1) to assess the potential susceptibility of about 5 to 10 plant species to infection by five species of *Phytophthora* commonly found at plant nurseries in the southeastern United States, and 2) to determine the pathogenicity of each of the five *Phytophthora* species on the trialed plant species. Plant species that do not serve as hosts to *Phytophthora* species in greenhouse trials will be selected as candidates for use in vegetative buffers. Pilot-scale vegetative buffers will be installed onsite at nursery/greenhouse production facilities to quantify treatment efficacy in terms of sizing and plant densities to limit *Phytophthora* release and to determine seasonal variability.

**A Survey of Wounding Frequency among Trees found in Urban and Forest Environments**

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Trees are exposed to a variety of natural and/or anthropogenic factors that expose internal wood to the external environment, resulting in decay and tree failure. Urban trees are exposed to improper landscaping practices, pruning cuts, soil contamination, and even vandalism. Forest trees are less impacted by anthropogenic activities, but are still susceptible to weather-and pest-pathogen-related damages. To compare these two environments, we measured seven types of common wounds in maple (*Acer*), hackberry (* Celtis*), ash (*Fraxinus*), oak (*Quercus*), and elm (*Ulmus*). Urban environments surveyed included college campuses...
and industrial plazas; forest environments included city and state parks. Trees in urban environments had a higher frequency of wounding compared to forest trees. We saw interspecific variation in total number of wounds, wound area, girdling roots and pruning cuts. Since wounded trees are more likely to fail, posing a risk to humans and property, a reevaluation of arboricultural pruning cuts. Since wounded trees are more likely to fail, posing a risk to humans and property, a reevaluation of arboricultural management practices in urban environments is needed.

An Approach for Integrated Pest Management of Chilli Thrips, *Scirtothrips dorsalis* Hood, on Ornamental Roses

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The chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) is a recent invasive insect in the southeastern United States, which is known to infest more than 100 plants species, including vegetables, fruits, and ornamental plants. *S. dorsalis* has become the most important insect pests affecting Knock-Out® roses in nursery and landscape. Three components of an integrated pest management (IPM) of *S. dorsalis* on roses under nursery conditions were addressed. First, for monitoring the pest population, a sampling plan based on visual damage on fresh foliage terminals was developed. Second, entomopathogenic fungi, botanical insecticides, and horticultural oils were tested against *S. dorsalis*. The effectiveness of these biopesticides applied singly or in rotation programs reduced *S. dorsalis* populations by 48% to 72%. More effective control (87% to 94%) was achieved in a rotation programs that included spinosad. Finally, pruning was evaluated as a cultural control practice against *S. dorsalis*. Pruning reduced, but did not completely eliminate an established infestation of *S. dorsalis* on roses. However, the combination of pruning and biorational insecticides was more effective than pruning alone. This research highlights aspects of the management of *S. dorsalis* on roses that could be incorporated into an IPM program for the nursery industry.

Biosolids: Characteristics and Potential in the Southeastern United States

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Biosolids are the residuals after processing of sewage sludge. They are suitable for land application, including many farm and horticultural applications. Although there have been instances where contamination has resulted in inappropriate use of biosolids, well-prepared biosolids products can be handled and used safely within the guidelines governing them, and when used at appropriate agronomic rates. The use of biosolids still faces opposition but there are many opportunities to take advantage of the fertilizer and soil conditioning value that biosolids offer southern horticulture.

Chilli Thrips (*Scirtothrips dorsalis* Hood) Population Growth in ‘Double Red’ Knockout Rose as Affected by Controlled Release Fertilizer Regimes

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Two greenhouse experiments were conducted to determine the population growth of chilli thrips in response to various nutrient statuses of ‘Double Red’ Knock Out rose under the ‘choice’ and ‘no-choice’ conditions. In the ‘choice’ expt., a total of nine 3’ x 3’x 3’ cages each having three plants placed with leaf overlapping were used. Each of the three plants was fertilized with a controlled release fertilizer (13N–5.6P–10.8K) at 1, 3, or 6 g N/pot. Plants were inoculated with 20 adults per plant at 4 weeks after fertilization began. In the ‘no-choice’ expt., the same fertilizer was applied at 0, 2, 5, and 8 g N/pot at plants individually caged inside 5-gal buckets. Plants were inoculated with thrips at the same rate and timing as the ‘choice’ expt. In both expt., at the time of inoculation, increasing fertilization rate resulted in increasing tissue N% and P% concentrations, establishing various plant nutrient statuses. The adult thrips population at 4 weeks after inoculation was not affected by fertilization rate in the ‘choice’ expt., but was higher in plants fertilized at 5 g N/pot in the ‘no-choice’ expt. The immature thrips (nymphs, pre-pupa and pupae) population was higher in plants fertilized at 3 g N/pot than in those fertilized at 6 g N/pot in the ‘choice’ experiment, but was not affected by fertilization rate in the ‘no choice’ expt. Thrips damage assessed was positively correlated with the number of immatures under the ‘choice’ condition. However, no correlation was found with adult or immature under the ‘no-choice’ condition. Plant quality was affected by fertilization with 3 to 6 g N/pot resulted in quality 1-gal ‘Double Red’. Overall, fertilization rate affected plant quality more than thrips injury at the present inoculation rate.

Cowboy Bunk Bed Gardens: A Raised Bed and Container Hybrid

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Gardening offers benefits such a source of physical activity, improved diet and enhanced family interactions. In many communities gardening is not accessible to all who would like to participate for reasons including location availability, inadequate soil resources or gardener physical limitations. Some rural communities are classified as food deserts and, although Oklahoma Cooperative Extension Service (OCES) programs educate on the
importance of fruits and vegetables in a healthy diet, these foods are often not within reach of many consumers. Thus, there is a need to find ways to increase the availability of fresh produce in these communities and OCES is working to make gardening more accessible. Cattle feed bunks have characteristics that appeared to be suitable for use as elevated container gardens. These are readily available in the area at reasonable cost (about $150). During 2015 feed bunks were used to assess suitability for use as container gardens. Commercial vegetable plug mixes and mixtures of these with compost and finely chopped pine bark were used as growing media. Referred to as Bunk Bed Gardens, the units were used at the Lane Elementary School and the Choctaw Nation Community Center in Atoka County, and at a community garden located at the Johnston County Health Department. Using these container gardens, normal productivity was obtained for lettuce, tomato, Swiss chard, eggplant, pepper, cucumber and green beans. This gardening approach was also found to be useful for educating children on vegetable gardening and consumption. At the Lane Elementary School a single Bunk Bed Garden was large enough for 20 children to each plant a vegetable (lettuce, chard, kale or strawberry) and, as a group, maintain the garden until harvest time. The group then harvested crops and made a salad for all to enjoy and the teacher discussed the importance of including fresh vegetables in the diet. Work will continue in 2016 with further evaluation of vegetable productivity in this system and the development of irrigation timing and mineral nutrition management. This project was partially funded by USDA’s Supplemental Nutrition Assistance Program (SNAP).

Developing a Professional Approach to Home Horticulture Problem Solving for County Agents

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Providing agents with the training necessary to better handle home horticulture questions is of vital importance to Extension’s mission. State specialists can and do receive inaccurate information from agents about county horticulture problems that delay accurate diagnosis. An eight hour in-service training was conducted in each of the four Extension districts at a location that would provide classroom and field instruction to better equip agents with the tools and resources to handle these questions. The objectives were to train these agents how to ask the right questions, collect the right data, take pertinent samples and/or photographs, and contact the proper specialist/Extension lab; or have the confidence to make their own diagnosis and recommendation. A grant provided funding for these trainings and the equipment and materials each agent participant received. Pre and post evaluations indicate that there was a significant difference (ANOVA) between level of knowledge before in-service and after. On a scale of 0 to 5 with 0 being “nothing” to 5 being “a lot” the average before level of knowledge was 3 and the average after was 4.69. When the provided materials were rated for usefulness (0 = no use; 5 = extremely useful) all were rated 4.5 or above, except the microscope and pH meter which were rated 3.75. Comment feedback on the training was positive with the format of classroom instruction in the morning and field diagnosis in the afternoon being highly preferred. Many agents requested follow-up field trainings scheduled at different times of the year so different seasonal problems could be addressed.

Effects of Substrate Gravimetric Water Content from Transplant to Finished Stage on Impatiens walleriana ‘Xtreme Red’

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Growers differ on the ideal substrate moisture content for early stages of bedding plant production. In this experiment, Fafard 3B was maintained at five GWC levels to determine effects of Impatiens walleriana growth as well as depth of root growth within substrate profile. Plugs were potted into 6” containers and irrigated initially to 64%, 68%, 72%, 76% or 80% GWC. Plants were irrigated by hand daily using a 60 mL syringe to bring it to its target GWC. The experimental design was a completely randomized block. Substrate pH and EC were collected at 3 and 6 weeks after potting (WAP) while size indices were collected weekly. At 6 WAP, shoots were harvested and containers were brought back to container capacity and placed in a freezer at 28.4 °F. After freezing, root balls were divided in half using a machete and rubber mallet. An increase in GWC resulted in an increase in size index, shoot dry weight, and root dry weight. Substrate maintained at 80% GWC resulted in the highest percentage of roots in the bottom half of substrate profile. Results may differ in finer textured substrates that have less air space. Further research will be done in cooler months and with a bark-less substrate.

Establishing an EarthBox Demonstration in South Mississippi

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The interest in vegetable gardening in south Mississippi has been increasing for last several years. But a common misconception is that a large amount of land is required for the vegetable garden. In fact, more home gardeners with limited backyards are becoming interested in growing vegetables in containers. Growing vegetables in containers is a way for those with limited space, maybe only a porch or patio, to have a fresh harvest. This is especially true in the urban areas of Mississippi where
many homeowners have never gardened before. An effort at the Coastal Research and Extension Center for several years has been to provide home gardeners with examples of vegetable gardens suitable for typical small urban yards. One of the easiest ways for novice gardeners to get started is with sub-irrigated containers. Coastal Research and Extension Center is using a commercial product called EarthBox for our demonstration area. This demonstration area will highlight seasonal homeowner crops grown in sub-irrigated containers and be a trial site for statewide vegetable and ornamental plant trials.

**Evaluation of Zinc and Phosphorus Fertilizer on Celosia Grown in Nigeria**

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Celosia (Celosia argentea L.) are annuals used as both ornamentals and vegetables in Nigeria that are well adapted to difficult soil conditions and hot weather. In Nigeria, dietary zinc (Zn) deficiencies are common, and Zn fertilization is needed on sandy, acidic soils. In this study, Celosia was grown under different Zn fertilization programs to determine the effects on plant growth and leaf nutrient content. Sixteen celosia plants were planted in pots arranged in a randomized complete block design with four pots per block. Each pot was filled with native topsoil and ZnSO4 was added at one of the four fertilizer levels: 0, 50, 100, or 150 mg-L⁻¹, with each fertilization treatment appearing once per block. A 15–15–15 fertilizer was added at a rate equivalent to 80 kg N·ha⁻¹. After growing for six weeks, roots and shoots were harvested and dried at 80 °C for 72 h. Soil and plant tissues were analyzed for Zn and P using atomic absorption spectrophotometry. Zinc fertilizer did not affect plant height or leaf number. However, significantly higher shoot Zn levels were found in plants fertilized at the 100 and 150 ppm levels. Shoot dry matter was highest at the 50 and 100 ppm Zn.

**The Experiences Managing a Multi-Institutional Public-Private Partnership Research and Outreach Program**

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The National Strawberry Sustainability Initiative (NSSI) was a 3-year public-private partnership between the Walmart Foundation and the University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability. This competitive grants program encouraged innovation and outreach at public and land grant universities to support the sustainability of the US strawberry production system. The goal of the NSSI was to improve the sustainability of the system from production through the supply chain to consumers. Phase I taking research from laboratories to demonstration awarded 20 projects approximating $2.4M. Significant outputs and impacts were highlighted in the e-book “Moving the Needle: Accomplishments of the National Strawberry Sustainability Initiative 2013–2014.” Select achievements included the development of an e-learning tool, an online diagnostic tool, and an interactive budget tool; patenting two Rutgers-developed cultivars; expansion of strawberry production areas and season extension in Texas, Kansas, Arkansas and Nebraska; and development of over 60 project and production videos on the NSSI YouTube channel. Phase II focused on moving technology from demonstration to practice in conjunction with more than 30 strawberry growers across the United States with $850,000 awarded to six projects. Projects concluded in June 2015 with accomplishments highlighted in the e-book “Success in the Field: Accomplishments of the National Strawberry Sustainability Initiative 2014–2015.” Select achievements included the expanded testing of new and potential strawberry cultivars for the mid-Atlantic region; addressing grower-specific needs for organic production in FL; continued high tunnel and greenhouse production research; implementation of sustainable soil management practices; and field-testing of remote sensing for frost protection and irrigation management. The e-books and resources are accessed at: http://strawberry.uark.edu/. The next phase of the NSSI will capitalize on the network of scientists, growers and suppliers developed through the NSSI and leverage the momentum of the initial funding and project impacts through the development of a USDA Specialty Crop Research Initiative project.

**Landscape Fabric Performance and Effect on Soil Organic Matter**

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Gardeners use landscape fabrics (LF) to suppress weeds, frequently under organic mulches. Some studies have indicated that landscape fabrics under mulch may prevent the movement of organic matter and soil nutrients into the soil. To evaluate the relationship between LF and soil organic matter (SOM), fabric and mulch combinations were installed at three locations, a fine sandy loam in Campbell, TX, a silt loam in Commerce, TX, and a heavy clay in Greenville, TX. Beds were tilled and no amendments added. Beds were arranged in a randomized complete block design, with four blocks per location, and a fabric/mulch combination from each of the following: 1) no mulch, no fabric (control); 2) mulch only; 3) black LF; 4) gray LF; 5) black LF with mulch; and 6) gray LF with mulch. Each bed was planted with a single crepe myrtle, and irrigation applied weekly using drip irrigation. At the end of years one and two, 5 cm deep soil samples were taken and analyzed for SOM using the loss on ignition method. SOM was higher (6.35%) at Commerce than Greenville (4.28%), though a reason remains unclear. However, there were no differences found between the various fabric/mulch combinations. Although wide variation...
existed between treatments (6.47% to 4.13%), these were not significant, because of a high within treatment variation, likely due to the high presence of weeds in LF treatments. Also, two years may not provide sufficient time for decomposition of mulches and movement into the soil profile.

Plants with Potential: A New LSU AgCenter Ornamental Plant Material Awareness Program

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The LSU AgCenter’s Hammond Research Station (USDA Hardiness Zone 8B) created a new outreach program in 2015 to annually introduce and distribute unfamiliar, non-patented plants to Louisiana’s ornamental nursery and landscape industry. Plant species or varieties selected for the program currently suffer from limited or no commercial availability and use in the state, but evidence suggests they have excellent landscape performance potential in the challenging Gulf South climate. While this program is not an official trial study, the industry may benefit from learning about and receiving these stock plants for evaluation of growth characteristics or customer interest. Nurseries may be able to broaden their product lines and landscapers could diversify their plant material palettes to enhance profitability, while increased distribution of these plants will help preserve unique varieties. Use of plant material free from propagation restrictions can present a significant cost savings and lower risk of offering alternative selections. Participants in the program receiving stock plants include small to medium size wholesale growers, retail nurseries, landscapers, Master Gardener plant sale groups, professional horticulture organizations, public gardens and other university or research facilities. Plants in the program are generally easy to propagate and were chosen based on observed landscape performance of existing plant material at the Hammond Research Station. Plant sources include heirloom varieties, passalong favorites, older or forgotten cultivars, limited regional releases, and new non-patented releases. Nine plants were propagated and distributed during 2015: ‘Kapiolani Bronze’ copper plant (Acalypha wilkesiana), ‘Musaica’ copper plant (Acalypha wilkesiana), ‘Barbara Rogers’ begonia (Begonia sp.), ‘Belle Starr Gold’ lantana (Lantana camara), ‘Mary Helen’ geranium (Pelargonium sp.), ‘Nova’ pentas (Pentas lanceolata), ‘Florida Dwarf Rose’ purslane (Portulaca oleracea), ‘Silke’s Dream’ salvia (Salvia sp.), and ‘Trailing Yellow’ turnera (Turnera ulmifolia).

Postemergence Control of Pilea microphylla (Artillery weed) in Container Nursery Production

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Artillery weed (Pilea microphylla), also known as artillery fern or gunpowder weed, is a weed of increasing importance in Florida and other southern states. Artillery weed is primarily found in partly shaded areas but can also grow in sunny locations if irrigation and or adequate rainfall is provided. It has become a nuisance in walkways, aisles, ditches, and in container-grown nursery crops, but is not listed on any herbicide label and little information is available on herbicide efficacy for this weed. The objective of this trial was to evaluate selected nursery herbicides for postemergence control of artillery weed. Nursery pots were filled with a standard pine bark:peat substrate plus amendments and approximately 150 artillery weed seeds were surface sown and allowed to grow for approximately 2 months at which time all plants were approximately 3.5 to 4 in. (8.9 to 10.2 cm) in height and had flowered. The following herbicides were applied at generally their highest recommended label: sulfosulfuron (0.06 kg/ha), sulflurazone (0.42 kg/ha), indaziflam (0.07 kg/ha), diquat (0.56 kg/ha), oxadiazon (granular) (4.48 kg/ha), glyphosate (3.36 kg/ha), pelargonic acid (4.71 kg/ha), flumioxazin (0.43 kg/ha), and dimethenamid-p (1.68 kg/ha). A non-treated control was also included. Data collected included visual control ratings (0 to 10, 0 = no control, 10 = dead plant) at 1, 2, and 4 weeks after treatment (WAT). At 4 WAT, percent control was calculated for each treatment using the formula [(1-(Fresh weight of treated/fresh weight of non-treated))*100]. Results showed the best control was achieved with diquat (100% control), glyphosate (98% control), pelargonic acid (100% control), flumioxazin (100% control), dimethenamid-p (92% control), and oxadiazon (79% control) followed by sulflurazone (65% control) and indaziflam (61% control). Sulfosulfuron did not provide effective control and was similar to non-treated plants. Results from this trial suggest that several active ingredients already labeled for use in nursery crops and landscapes can be used for artillery weed management. Oxadiazon (granular) and dimethenamid-p are also labeled for over-the-top use and could be prove to be valuable tools for controlling artillery weed already growing in nursery containers. Future work will be needed to determine preemergence efficacy of nursery herbicides as well as multiple other active ingredients and formulations at various rates in order to develop the most effective control recommendations for this species.

Stem Cutting Propagation of Aromi Series Deciduous Azaleas

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The Aromi Series of hybrid azaleas are heat tolerant fragrant azaleas that thrive in southeastern U.S. climates and tolerate full sun or shade. The objective of this research was to compare the effect of IBA concentration on the rooting of stem cuttings of three cultivars of Aromi Series deciduous azaleas. Terminal softwood stem cuttings (10–13 cm length) were taken from three Aromi series azalea cultivars, ‘Lemonade’, ‘Radiant Red’, and ‘Great Balls of Fire’, on 12 May 2015. The basal 2.5 cm of each cutting was treated for 5 s with one of seven water-soluble solutions of IBA ranging from 2,500 mg L−1 to 10,000 mg L−1 in 1,250 mg L−1 increments. Intermittent mist was applied for 10 s/6
min for the first 10 days, 10 s/15 min until rooting initiation, and 10 s/30 min for three weeks during root development. Cuttings were arranged in a greenhouse in Auburn, AL in a randomized complete-block design with six blocks and six cuttings per treatment per cultivar per block. Subjective root ratings were collected using a 0-5 scale: 0- Dead, 1- Callus has formed, 2- Root initiation, 3- Light rooting, 4- Medium rooting, 5- Heavy rooting. Rooting and subjective root rating were evaluated three times at 50 day intervals, on two cuttings per treatment per block per cultivar at each date. Root system diameter was measured 100 d after sticking. Rooting percentage and root system diameter were highest for ‘Radiant Red; ‘Great Balls of Fire’ and ‘Lemonade’ were similar. Rooting and root system diameter increased linearly with increasing IBA concentration and over time for all cultivars. Subjective root rating increased linearly with increasing IBA concentration for ‘Great Balls of Fire’ and ‘Radiant Red’; root rating for ‘Lemonade’ varied quadratically. Root rating increased over time for all cultivars. Regardless of IBA concentration or date, root rating was higher for ‘Radiant Red’ than the other two cultivars. If using IBA, growers could expect at least 50% rooting for these three cultivars of Aromi Series azaleas. Rooting percentages can be increased with increasing IBA concentration, and liners suitable for stepping up in to larger containers can easily be produced from cuttings in one growing season. Successful propagation of azaleas in this series should allow growers to expand production of these fragrant, deciduous azaleas.

Tolerance of Three Native Herbaceous Perennials to Repeated Short-interval Flooding

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Rain gardens are stormwater runoff filtration systems that also serve as attractive landscape features. Plants in rain gardens must be able to tolerate exposure to repeated short flooding intervals usually with no supplemental irrigation between flooding events. Previous research at Auburn University has screened a wide range of native landscape plant species for tolerance of flooding, however this work only included two herbaceous perennials and no ferns. The objective of this research was to evaluate the effect of repeated short term flooding on growth of four native landscape plant species. Two ferns, Osmunda cinnamonomea (cinnamon fern) and Polystichum acrostichoides (Christmas fern), and two herbaceous perennials, Chasmanthium latifolium (river oats) and Lobelia cardinalis (cardinal flower) were flooded for 48 h followed by 5 d of draining with no additional irrigation during draining or were watered as needed (non-flooded). There were a total of eight flood-drain cycles. Leaf area (LA), shoot dry weight (SDW), and size index (SI) [(height + widest width + width perpendicular the widest width) / 3] were measured at experiment termination. Plants were arranged in a completely randomized design with two replications. There were two runs (spring and summer) in 2015. Ferns were grown Mar.-May and May–July, and herbaceous perennials were grown Mar.-May and June–July. In the spring, flooding did not affect SI, LA, or SDW for any species in the spring. SI did increase from the beginning of the experiment to the end. In the summer, SI, LA, and SDW of C. latifolium were higher in flooded than nonflooded. For P. acrostichoides, SI was higher in nonflooded than flooded; otherwise there were no differences for LA and SDW for either fern. L. cardinalis suffered extensive foliage damage from an unidentified Lepidopteran insect in both spring and summer runs that prohibited sufficient data collection for this species, however this damage was not related to flooding treatment. Surviving L. cardinalis plants continued to grow and flower with no visible signs of stress. All species evaluated tolerated repeated short-term (48 h) flooding and would be suitable selections for use in rain gardens.

The Effects of Shade on Primocane Fruiting Blackberries in the Field

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This study was designed to test the effect of three levels of shade (0% [control], 30% and 50% shading) on flowering and fruiting of ‘PrimeArk-45®’ blackberries. The field study consisted of seven treatments with various levels of shade and differing dates of implementation: 1) an untreated control [CK]; 2) early shade 30% [ES30]; 3) mid shade 30% [MS30]; 4) late shade 30% [LS30]; 5) early shade 50% [ES50]; 6) mid shade 50% [MS50]; and 7) late shade 50% [LS50]. The 30% and 50% treatments were implemented 16 June [ES], 1 July [MS], and 15 July [LS]. Weekly measurements were collected on foliar gas exchange (CIRAS-3 Portable Photosynthesis System), chlorophyll content (Minolta SPAD®), fruit yield (g), and plant growth variables such as cane height (cm). The total cumulative berry weight (g) was greatest for LS50 and LS30 at the end of the experiment; ES50 and MS30 were intermediate while ES30 resulted in the lowest yield. The cumulative marketable weight (g) was greatest for LS30 while ES30 was lowest. The field study indicates that ES reduces crop yields compared to other treatments. LS30 treatment resulted in the greatest marketable yield, while LS50 recorded the greatest total berry yield in comparison to all other treatments. Overall, LS treatments resulted in higher yields and an extended harvest season compared to other treatments in this experiment. It was found that shade may be used to delay flowering and reduce heat stress, resulting in greater fruit production. However, some of the shade treatments resulted in reduced cropping. Continued research is needed to fully understand the effect of shade on blackberry production and physiology.

Identification of Sugars and Organic Acids in Arkansas Blackberry Genotypes that Impact Sensory Perception

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Five blackberry cultivars (Natchez, Osage, Ouachita, Prime-Ark® 45 and Prime-Ark® Traveler) and six advanced selections (genotypes) from the University of Arkansas Fruit Breeding Program were evaluated to identify individual sugars and acids in Arkansas-grown blackberries and to establish correlations between chemical components and descriptive sensory attributes. Trained descriptive panelists (n = 9) used modified Sensory Spectrum® methods to evaluate blackberries for intensity of basic tastes and feeling factors using a 15-point scale (0 = less and 15 = more of the attribute). Each panelist evaluated four berries of each genotype in duplicate. Composition analysis was done on juice of three-berry samples in triplicate. Organic acids and sugars of blackberries were identified and quantified by HPLC, and soluble solids (SS), titratable acidity (TA), pH and SS/TA were also measured. The individual acids isocitric, isocitric lactone, and malic, along with individual sugars fructose and glucose were identified and quantified. ‘A-2418’ had the highest sum of acids (2.12 g/100 g), highest titratable acidity (1.49%), and lowest SS (6.6%). ‘A-2491’ had the highest sum of sugars (7.87 g/100 g) and SS (10.9%). The sum of sugars was positively correlated with fructose and glucose (r = 0.99) and with descriptive sweetness (r = 0.75). The sum of acids was positively correlated with isocitric acid (r = 0.98), TA (r = 0.77) and metallic and astringent feeling factors (respectively, r = 0.62 and r = 0.60). Isocitric acid was correlated to TA (r = 0.77) and metallic feeling factor (r = 0.62). Isocitric acid was the major organic acid identified in blackberries from Arkansas. The content of sugars and acids was found to impact basic tastes and feeling factors in blackberries.

**Variation of Disease Symptoms Expression among Apple Genotypes to the Bacterial Disease Fireblight, *Erwinia amylovora***

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The hypothesis of this project was that variability in disease incidence in the apple orchard represents genotypic variability in resistance to the bacterial disease fire blight, *Erwinia amylovora*. However, this phenotype expression is environmentally dependent. Phenotypic variability was clarified by modeling changes in disease risk over time and analyzing variability in disease expression among apple genotypes. Weather data over the past century, 1900–2015, were analyzed with the CougarBlight disease risk model. Annual data from March 15 to May 15 (60 days) were analyzed to model disease conditions during peak flowering period. The number of days of “exceptional” and “extreme” disease risk were recorded. Data were analyzed by decade to identify long-term trends. Fire blight severity on a collection of apple genotypes was measured at the Arkansas Agriculture Research and Extension Center in Fayetteville, using two scales: the USDA severity scale and the Arkansas total damage rating scale. The orchard consists of 444 eleven-year-old apple trees representing 92 genotypes, replicated between two and four times across ten rows. Ratings were conducted by four evaluators, with at least two separate evaluations per tree. Subsamples were pooled and genotypes were evaluated with Tukey’s HSD test (JMP SAS®). The CougarBlight model shows an oscillating pattern but linear trend of risk days over the past century. Although the number of extreme days tended to decline, the number of exceptional days increased linearly over the past century. The total number of days being either extreme or exceptional increased significantly during the century from 19 days to 30 days out of 60, or 50% days with extreme or exceptional predicted ratings for the incidence of fireblight. The disease rating data indicated significant variability among genotypes (α = .05 using Tukey’s HSD test). Genotypes AA101 and ‘Jonathan’ were significantly susceptible to fire blight while genotypes AA134, AA184, and AA94 demonstrated strong field resistance to the disease.

**Assessing Financial Risks to Blackberry Production with an Interactive Decision Support Tool**


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The release of blackberry cultivars with improved fruit quality coupled with a growing consumer demand for blackberries have led to increased production in the United States. Although blackberry production is small in Arkansas compared with other regions, it is growing, having increased nearly 300 percent between 1997 and 2015. In recent years, researchers at the University of Arkansas have demonstrated that primocane-fruiting blackberry harvest can be extended with the use of high tunnels. Extending the production season of blackberry cultivars allows producers the opportunity to potentially receive better market prices early or late in the harvest season. However, entering into or expanding existing blackberry production systems, whether in field or in high tunnels, is not without financial risks. Blackberry producers can benefit from economically focused tools that help them assess potential production and marketing risks. In response to this need, the University of Arkansas System Division of Agriculture researchers have developed a user-friendly tool for estimating the present value of costs, returns and net returns to blackberry production over a seven-year period. This tool allows for the assessment of different types of production systems, including conventional and organic production as well as field and high tunnel systems. Unlike many existing agricultural budgeting program, this tool includes components that allow a user to conduct break even, sensitivity and risk analyses to help improve on-farm financial decision-making throughout the life of the blackberry operation.
Evaluating Salt Exclusion in ‘Black Spanish’ and ‘Blanc Du Bois’ Grapes

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Black Spanish and Blanc Du Bois are interspecific winegrape cultivars commonly grown in the southeastern U.S. due to their tolerance to Pierce’s Disease. They are most frequently grown as self-rooted vines, although the adaptability of their roots to various soil conditions has not been well characterized. In many regions, rootstocks are used to overcome challenges associated with soil, pests and diseases, and salinity. The objective of this study was to determine the relative capacity of Blanc Du Bois and Black Spanish to exclude sodium and chloride, two ions commonly found in saline irrigation water. Herbaceous cuttings of Blanc Du Bois, Black Spanish and nine common grapevine rootstock cultivars were rooted under intermittent mist, and grown in fritted clay in a greenhouse. A 25mM sodium chloride was applied daily for two weeks before the vines were destructively harvested. At harvest, vine necrosis was quantified by visual inspection of the leaves, and sodium and chloride concentrations were determined individually in the shoots and roots.

Examining Fiber and Seed Content of Southern Highbush and Rabbiteye Blueberry Genotypes Grown in Georgia

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In Georgia and in the southeastern U.S., two main types of blueberries are commercially grown: southern highbush (species complex between Vaccinium corymbosum L. and V. darrowii Camp) and rabbiteye (V. virgatum Aiton). Often southern highbush fruit are subjectively perceived to have higher fruit quality characteristics as compared to rabbiteye fruit. One of the main perceived differences is that rabbiteyes are thought to be seedier, and therefore less palatable, than highbush fruit. The main objective of this study was to measure the seediness and fiber content of southern highbush and rabbiteye cultivars commonly grown in Georgia. During the 2014 harvest season, fruit were harvested from the University of Georgia Blueberry Research Farm near Alapaha, GA from seven highbush cultivars: ‘Rebel’, ‘Star’, ‘Emerald’, ‘Farthing’, ‘Meadowlark’, ‘Legacy’, and ‘Camellia’, and from seven rabbiteye cultivars: ‘Vernon’, ‘Alapaha’, ‘Brightwell’, ‘Powderblue’, ‘Tifblue’, ‘Ochlockonee’, and ‘Premier’. Fruit were kept frozen at -15°C for approximately one year before seed extractions and fiber content analyses were conducted. For seed extractions, individual berry weight and diameters were taken, and extracted seed were classified into plump and shriveled categories and were counted. Total seed number and total seed weight were recorded. For fiber analyses, NDF, ADF, lignin, cellulose and hemicellulose were measured. Varieties were significantly different for all traits examined (P < 0.001). Highbush were significantly higher than rabbiteyes for all berry and seed traits measured, except for plump seed number and total seed weight (highbush were not significantly different than rabbiteyes for both traits) and for percent seed weight / berry weight (rabbiteyes were significantly higher than highbush, P < 0.0001). Rabbiteyes were significantly higher than highbush for all fiber traits examined (P < 0.0001). NDF and ADF were significantly correlated (P ≤ 0.05) to plump seed number in both highbush and in rabbiteyes. Additional correlations of NDF and ADF were observed with berry weight, total seed weight, and total seed number for rabbiteyes. Percent seed weight/berry weight was also correlated to ADF in rabbiteyes. Results from this study suggest contrary to subjective perception, rabbiteyes are not seedier than highbush, and that seed content may be an indicator of fiber content.

Interactive Sustainable Budget: A Tool for Developing Sound Raspberry Business Plans

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This poster introduces an interactive tool that can be used to simulate raspberry production. This tool is a Microsoft Excel spreadsheet template that calculates total costs and expected net returns for field or high tunnel production systems. The economic models components provide a framework for current or potential producers to build a base scenario and then analyze that scenario with respect to different market prices, yields, trellis, irrigation, high tunnel, machinery and equipment systems and pest management costs or changes to production and management systems for seven years. Inputs that can be edited, modified, or changed at any time. This tool estimates operating costs, fixed costs, total costs, and total returns expected when modifying production practices, production systems, cost values, and/or return values. Additionally, three different types of economic analyses (break even, sensitivity, and risk analyses) can be performed. This tool automatically calculates an estimated enterprise budget derived from values entered by the user and default values derived from research conducted at the University of Arkansas, Division of Agriculture’s Arkansas Agricultural Research and Extension Center in Fayetteville, AR. Results are breakdown in expected total costs and total returns over a seven-year period. They are also presented as individual years that can be modified to customize the budget. Results are presented in tabular and graphical forms that are updated automatically if any yearly input is changed. This tool might help developing sound raspberry business plans by helping producers to identifying and listing the production and marketing decisions that must be made and deciding which are most important based on simulating several potential scenarios.
Evaluation of Harvest Time and Storage Temperature on Postharvest Incidence of Red Drupelet Reversion Development and Firmness on Blackberry (Rubus L. subgenus Rubus Watson)

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Blackberry is increasing in importance in fresh-market sales in the United States. Industry expansion is based on improved cultivars that have the ability to be stored and shipped to distant markets. The University of Arkansas blackberry breeding program has released several cultivars that are important in the shipping industry. Further breeding is underway to provide additional cultivars for the shipping market. A major limitation in blackberry for postharvest handling is maintaining fruit firmness in storage. A second concern is red drupelet reversion (or simply reversion) in which drupelets change from black to red during storage. Blackberries in the in the southern U.S. often are harvested at high temperatures and quickly moved to cold storage. Little is known about harvest time (during hotter periods of the day) effects on postharvest handling potential and how this differs among genotypes or storage temperature. This study was undertaken to evaluate harvest time and temperature of storage on firmness and incidence of red drupelet reversion. ‘Osage’, a commercially available cultivar, was evaluated along with the firm breeding selection A-2453T. Fruit was harvested at two harvest times (7:00 am and 1:00 pm) and stored at two temperatures (1 °C and 5 °C). A-2453T showed a trend of firmer fruit despite warmer storage temperature. There was a trend toward lower incidence of reversion at the 7:00 am harvest time, although not significantly different from the later 1:00 pm harvest time. Further research is needed on this topic to better define harvest time (temperature) effects on blackberry genotypes and potential for successful postharvest storage.

New Large Fruited Rabbiteye Blueberry Varieties from the University of Georgia

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Two new large fruited rabbiteye blueberry (Vaccinium ashei Reade) cultivars have been recently released by The University of Georgia Blueberry Breeding Program. ‘Titan™’ (T-959, USPPAF 24135) is early-to-mid season, having exceptionally large berry size, good firmness, high yields, and excellent plant vigor. The new variety is estimated to have a chill hour requirement in the range of 500 to 550 hours, flowering and ripening with the rabbiteye varieties ‘Alapaha’ and ‘Premier’. ‘Titan™’ berry weight has averaged 3.0-3.5 g, and berries as large as 4.3 g have been obtained in young vigorous plants. Yield of 5-year-old plants has been as high as 10.2 kg/plant. ‘Titan™’ is moderately susceptible to fruit cracking/splitting under certain rainfall conditions during ripening. ‘Krewer™’ (T-1101, USPPAF), is early season with very large, flavorful berries. Plants of ‘Krewer™’ are very vigorous, with a slightly spreading growth habit, and yields have been very good. This new variety has an estimated chill hour requirement of 400-450 hours, flowering approximately five days earlier than ‘Titan™’ and ‘Premier’, and typically ripening several days before these varieties also. ‘Krewer™’ fruit average 2.9–3.5 g in weight, and have exceeded 3.8 g on vigorous bushes grown under good management. Other important fruit characteristics, including stem scar, color, flavor, and firmness are good to excellent for ‘Krewer™’, and the new variety is slightly susceptible to fruit cracking/splitting. Growers desiring very large fruited rabbiteye blueberries should consider trialing ‘Titan™’ and ‘Krewer™’ in areas where rabbiteye varieties are successfully grown. Both of the new varieties should be grown is a smaller tree with zig-zag branches and large thorns. Tree growth from planting in the field was greater than 4 foot for all but ‘Sugarcane’, which was slightly less than 4 foot. The diameter of the trunk slightly above the graft had increased more than 25 mm for all but ‘Sugarcane’, which was less than 20 mm. Small flowers appeared in April of each year and continued into July. Minimal disease incidence and late season leaf feeding by insects were observed in both years. Diseases were identified as Cercospora, Phoma and Colletotrichum spp. Root knot, reniform and other nematodes were detected in low amounts; however, the importance of these nematodes could not be established because there are no thresholds for Jujube. In 2014, average yield was higher for ‘Sugarcane’ with 764 grams while ‘GA866’ produced no fruit in both years. The wet/rainy Spring 2015 appears to have reduced fruit set. Also, in 2015, most fruit were at the top of the trees and were not ready to be harvested until late September; while, in 2014, fruit harvest was from late July through September. Poor fruit set in the second year raised concerns about reliable production under Mississippi conditions. Taste trials ranked fresh fruit as 3.3 and dry fruit as 3.9 in a scale of 1–5, with 5 being liked very much. Although acceptance was limited among panelists, Jujube may have niche market for ethnic groups with a particular interest for the fruit.
with compatible rabbiteye varieties to facilitate cross pollination. Propagation rights controlled by University of Georgia, Innovation Gateway, Boyd GSRC Bldg, Athens, GA. 30602-7411.

Optimizing Fertilization of Young Peach Trees: Year One
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Recommendations for optimum fertilization (doses and frequency) in peach orchards during tree establishment are not consistent in the literature. In this field study, the effects of different fertilization treatments (traditional, split, and reduced) are being assessed. After the first year, trees that received reduced or split applications showed similar trunk cross-sectional area as trees fertilized with the traditional applications. More data are needed to conclude if reduced doses during the first two years may be more efficient than current recommendations.

Performance of Recently Released Rabbiteye Blueberry (Vaccinium ashei) Cultivars and Selections in North Alabama
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Blueberries are a high value fruit crop that is becoming increasingly popular worldwide. Alabama’s blueberry farm gate value has increased by approximately 13% in the last decade. Proper cultivar selection is one of the first and perhaps the most important decision a grower can make when planting blueberries. The University of Georgia Blueberry Breeding Program has accelerated development of blueberry varieties in the past 15 years to facilitate commercial and home garden demands for new varieties. A new large-fruited rabbiteye blueberry cultivar named ‘Titan’ with was developed and released in 2010. Rooted plants from ‘Alapaha’, ‘Brightwell’, ‘Titan’, ‘Vernon’, and selections ‘03-06’, ‘T-611’, ‘T-743’, ‘T-957’, ‘T-965’, each represented by 5 plants were introduced in 2011 to study the plant development and productivity at the specific growing conditions of North Alabama. Blueberries were planted at the North Alabama Horticulture Research Center (NAHRC), Cullman, in 2011 in a RCBD. Our results suggest selection ‘03-06’ had the highest yield (2013-2015) of 16.1 kg/plant, followed by ‘Titan’ (13.2 kg), and ‘T-743’ (12.8 kg). ‘Titan’ and selections ‘T-965’ consistently had the largest fruit size during the period of study. ‘Vernon’ and ‘T-957’ also produced large size berries in some seasons. Berries of ‘T-965’ matured very early in the season. During the initial years of establishment cultivars ‘Titan’, ‘Brightwell’, ‘Vernon’, and selections ‘T-965’, and ‘T-957’ were highly productive.

Postharvest Quality Comparison of High Tunnel and Field-Grown ‘Natchez’ Blackberry
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Studies have shown that high tunnels offer a much different set of growing conditions for berry production than a traditional field setting. This objective of this project was to analyze the quality of ‘Natchez’ blackberries grown in a high tunnel (HT), tunnel-in-tunnel (TNT), and field after one week of refrigerated storage. Samples of 25 marketable berries, randomly selected from each replication of each treatment, were used for analysis. Berries were analyzed for the following qualities: average berry weight, soluble solids, titratable acidity, leakage, and red drupe reversion. The HT samples lost almost 10% of their weight during storage, which was significantly higher than the 6% field berries lost. Citric acid levels (calculated from titratable acidity values) decreased significantly for all treatments: HT lost 17%, field 18%, and TNT 11%. When changes in citric acid levels were looked at by week, both field and HT treatments saw a general decline in the percentage lost as the harvest season progressed. Leakiness means across the harvest season were not significantly different for any treatment. However, when means were grouped by week, the field showed significant weekly change from and from the HT means. HT leakiness trended slightly upward each week. Red drupe counts for TNT were significantly less than the field or HT. Almost 50% of TNT berries had one red drupe or fewer. Our data suggests that for some blackberry quality metrics such as leakiness, red drupe count, and post-storage weight loss, environmental effects not present in a high tunnel could contribute to increased overall berry quality.

Companion Planting with White Yarrow or Feverfew Inconsistently Affects Squash Bug Populations on Summer Squash
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White yarrow (Achillea millefolium L.) and feverfew (Tanacetum parthenium (L.) Sch. Bip.) were tested as companion plants with summer squash (Cucurbita pepo L. cv. Lioness) for control of squash bug (Anasa tristis DeGeer). Six total experiments over three sites used a set of four treatments: early-season vented row cover, no herbs; companion planting with white yarrow, no row cover; companion planting with feverfew, no row cover; and a control with no row cover and no herbs. A study at Perkins, OK in 2015 included a control and four combinations of squash row arrangement and feverfew planting time. In 2013, companion planting with feverfew reduced total squash bugs by 48% compared to the control. However, this difference was
The Effect of Nutrient Solution Electrical Conductivity on Growth and Tip Burn Occurrence on Three Hydroponically-Grown Lettuce Cultivars

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The objective of this study was to test the effect of electrical conductivity (EC) on growth and tip burn occurrence on three hydroponically-grown lettuce cultivars. The cultivars ‘Rex’, ‘Bambi’ and, ‘Buttercrunch’ lettuce were grown using the University of Arkansas standard fertilizer formulation at an EC of 1.0 dS/m, 1.2 dS/m, 1.4 dS/m, 1.6 dS/m, and 1.8 dS/m. The pH was maintained at 5.9 for all treatments. Data collected were fresh weights and dry weights of lettuce heads on the day of harvest (5 weeks), and the occurrence of tip burn using a 5-point scale with 1 = no tip burn and 5 = significant tip burn on most leaves. The highest and lowest fresh weights for ‘Rex’ were 143.0 g and 72.4 g, respectively, at an EC of 1.4 dS/m and 1.0 dS/m. The highest and lowest fresh weights for ‘Bambi’ were 91.2 g and 63.6 g, respectively, at an EC of 1.8 dS/m and 1.0 dS/m. The highest and lowest fresh weights for ‘Buttercrunch’ were 89.8 g and 61.3 g, respectively, at an EC of 1.4 dS/m and 1.0 dS/m. Average fresh weights with increased from 1.0 dS/m to 1.4 dS/m then decreased at 1.6 dS/m and increased again at 1.8 dS/m. The highest and lowest tip burn scores for ‘Bambi’ were 3.5 and 2.2, respectively, at an EC of 1.8 dS/m and 1.0 dS/m. The highest and lowest tip burn scores for ‘Buttercrunch’ were 2.2 and 1.5, respectively, at an EC of 1.8 dS/m and 1.0 dS/m. The tip burn scores recorded for ‘Rex’ were 1.0, respectively, for all EC treatments. Tip burn occurrence in hydroponically-grown lettuce was not significantly affected by nutrient solution EC, but was affected by the cultivar.

Improving Soils with Winter Cover Crops Before Planting Pumpkin (Cucurbita pepo)

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Winter cover crop included hard red winter wheat (Triticum aestivum L.), crimson clover (Trifolium incarnatum), and Austrian winter pea (Pisum sativum arvense), a combination of crimson clover with Austrian winter pea, and a non-planted control were tested for their effect on soil organic matter and crop responses. All cover crops were terminated in mid-May using a postemergence herbicide tank-mix followed by mowing, strip-tilling with a 6’ wide rototiller down the center of each 20’ wide plot space in early June with soil samples being collected from each plot on the same day. All plots were rototilled a second time then bedded using a mulch layer bedder while laying a single drip irrigation tape per row center for irrigation, but no mulch was applied. Plots were direct seeded to Mustang PMR hybrid pumpkin with 10 feet between-row centers, 2.5’ spacing between planting spaces (two seeds/space) were planted down the row the third week of June. A preemergence herbicide application was made over the top of the seeded beds following planting (halosulfuron-methyl) at 0.024 lbs. a.i. per acre. Crop nutritional needs were met with a total of 52 lbs. of nitrogen per acre. Pumpkins were harvested twice, individual pumpkins were weighed to determine an overall plot yield and to determine number and weight of fruit per plot. Marketable yield ranged from a low of 17,642 to 21,181 lbs. of fruit/acre. The highest yielding treatment was the winter pea-crimson clover mixture, but there were no differences in yield between treatments. Average weight per fruit ranged from 13.7 to 15.9 lbs./fruit with crimson clover cover crop having the highest weight. In conclusion, the pumpkin crop appeared more vigorous and had a tendency to yield slightly more when winter legumes were used as cover crops compared to winter-wheat, but if increasing soil organic matter is the issue, then the winter wheat cover was the treatment with the highest soil organic matter levels in the study.

Evaluation of Lettuce Cultivars for Use in Hydroponic Greenhouse Crop Production

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Using a nutrient film technique system, 34 cultivars of multiple types of Romaine, butterhead, and leafy green lettuce were grown and evaluated for their performance in a greenhouse environment. The cultivars were grown for a period of 5 weeks in the final NFT system. All plants were grown using the University of Arkansas standard leafy greens fertilizer formulation at an EC of 1.4 dS/m and pH of 5.9. At harvest, shoot height, weight, circumference, diameter, fresh shoot weight, and dry shoot weight were determined. The Romaine type with the longest leaves was ‘Ridgeline’ at 32.8 cm. The Romaine type with the largest biomass accumulation was ‘Sparx’ at 205.5 g. The leafy types with the highest biomass accumulation were ‘Red Sails’ at 194.7 g.
g, followed by ‘Green Star’ at 182.2 g. The leafy type with the largest head size was ‘Green Star’ with a diameter of 35.6 cm and circumference of 111.3 cm. The butterhead cultivar with the largest head size and biomass accumulation was ‘Sylvesta’ at 27.7 cm and 164.3 g, respectively.

**Louisiana Sugarcane Bagasse as a Natural Mulch for Yellow Squash Production**


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Louisiana processed 12.8 million tons of sugarcane in 2014, producing 1.5 million tons of raw sugar and an estimated 3 million tons of bagasse. Bagasse is the fibrous material remaining after removing the juice from the sugarcane delivered to the mill. Typically, Louisiana sugarcane mills burn a portion of the bagasse to heat boilers to steam power the mill for grinding and sugar processing. The balance of the bagasse is stored at the sugar mill where it accumulates until used for fuel during the next year’s harvest. Sugarcane mill owners, operators, and associated researchers have investigated and employed various uses for the sugarcane bagasse, including pelletizing the bagasse into briquettes. In Spring 2015, research was conducted to investigate the use of sugarcane bagasse as a natural mulch for vegetable production. The experiment compared sugarcane bagasse mulch, black plastic mulch, and no mulch (control) for suitable mulching treatments for squash (Cucurbita pepo L.) production. The experiment included the 3 mulching treatments, 4 replications, 3 rows/plot, 70 inch row spacing, and 25-ft. plot lengths. Following application of the mulches, yellow squash var. ‘Straightneck’ seeds were direct seeded 1.5 ft. apart the length of each plot. Squash fruit was harvested three times a week for a total of 19 harvests, June 3 to July 15, 2015. Combining the 19 harvests, the plastic mulch produced a greater number of marketable fruit/acre and fruit/plant, which resulted in a 5 and 9 tons/acre yield advantage compared to the control and the sugarcane bagasse mulch, respectively. There were no differences among the mulching treatments for unmarketable fruit yields (tons/acre, fruit/acre, and fruit/plant). Further research will investigate the impact of mulching treatments on fruit production across the harvest season, as well as evaluating the influence of allelopathy by the sugarcane bagasse on cucurbit growth.

**Season Extension of Bok Choy in Organically Managed High Tunnels in North Carolina**

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High tunnels are effective tools in achieving season extension of vegetable crops. Bok choy is a common leafy vegetable in the American diet, especially for the ethnic groups such as Asians. Organic bok choy can be grown successfully and profitably in high tunnels, but information on planting dates is limited in hardiness zone 7&8 of North Carolina. The objective of this project was to determine the best time for planting bok choy in high tunnels for both spring and fall seasons. Cultivars Shiro and Win-Win Choi were tested in high tunnels located in Greensboro (zone7) and Goldsboro (zone 8) for spring and fall of 2014 and 2015. Treatments include three sequential sowing and transplanting dates that were 10 days apart starting from late January or mid-September. Both cultivars were transplanted from seedlings raised in a greenhouse. Seedlings were planted in 30” wide raised beds (three rows), with a row spacing of 8” and in-row spacing of 6”. Beds were irrigated with two rows of 5/8”, 8 mil, 6” emitter spacing drip tapes. Plastic mulch was not used in this research. The high tunnels are 90’(length) x 36'(width) x 5’(side wall) with single (Greensboro) or double-layer (Goldsboro) 6-mil polyethylene films. Temperature inside the high tunnel was managed between 40 °F to 75 °F through opening/closing sidewalls and applying row covers when temperatures inside the high tunnel went below 50 °F. The experiment was conducted as a split-plot design with three
replications and cultivars being main plots and planting dates as split plots. A total of 30 seedlings were planted in each split plot. Results indicated that late February to mid-March would work best for spring planting in both zones; while late October planting would be better to further extend the winter market. A farmer should consider all planting dates for continuous supply of fresh bok choy to local markets. There are significant differences between the two cultivars in terms of the first harvest date and marketable yield. ‘Shiro’ would bolt easily in spring but not in fall. ‘Win-Win’ could grow very large but still with good eating quality. Our research proved that bok choy could be a profitable crop for organic high tunnels, if cultivars were carefully chosen.

High Tunnel Systems for Spring Organic Lettuce Production in Georgia

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Growing horticultural crops under high tunnels is gaining in popularity because they offer season extension capabilities while simultaneously increasing opportunities to increase product quality. However, the existing body of literature for high tunnel production does not address the rapidly fluctuating temperatures and quick seasonal transitions from spring to summer in the Southeast region. The goal of this study is to investigate the performance of multiple butterhead lettuce cultivars for spring production under organically-managed high tunnels compared to the open field in Georgia. Two commercial-size high tunnels (9 m x 29 m) and an adjacent field area was utilized. The experiment was a split-split-plot design (growing system, planting date, cultivar) with four replications. Data was collected for marketable and non-marketable yield (i.e., number and weight) of lettuce heads. Planting dates were three weeks apart from each other. Disease incidence was tracked over time and microclimate data was recorded including air and soil temperature, relative humidity, photosynthetic photon flux, and leaf wetness. The following preliminary results reflect the first year of a two-year study. There was no significant difference among average marketable yield per plot for the high tunnel and field system or among the three different planting dates. A system*cultivar interaction was present within the high tunnel system indicating that ‘Adriana’ had a greater marketable yield compared to ‘Pirat’ and ‘Red Cross’ (P < 0.01). The average head weight was greater for the first and second planting dates compared to the third planting date (P < 0.01). The most common disorders observed were lettuce drop (caused by Sclerotinia sclerotiorum), bolting and tip burn, in descending order. The first planting date had a greater incidence of lettuce drop (15%) compared to the second (5%) and third dates (0.6%) (P < 0.001). The 2015 spring season (March–May) was 1.5 °C warmer than the 20th century average for this region. On the coldest night during the experiment (3/29), when row covers were draped over the plants in both systems, the high tunnel air temperature was a minimum of 5 °C warmer compared to the field system. Additionally, the average photosynthetic photon flux in the high tunnel system was approximately 32% lower than the field system while the average relative humidity was similar (± 2%) in both systems.

Selecting Suitable Romaine and Leaf Lettuce Varieties for South Georgia

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Due to shipping costs and increased interest in providing more locally sourced produce, there has been an increase in demand for South Georgia farmers to grow romaine and leaf lettuces (Lactuca sativa). In general, the climate in the region has not been found to be suitable for the consistent production of lettuce, despite large scale production of a wide range of leafy greens found primarily in the Brassicaceae family. In this study seven-week-old seedlings were transplanted on 11 Mar, 2014, into bare ground plots. The study was arranged in a randomized complete block design with three replications of each variety. Initial harvests were conducted on 4 May and continued for approximately 10 d. A second trial with 26 varieties was planted 28 Apr. with the primary intention of evaluating bolting tolerance. ‘Coastal Star’ was the highest yielding romaine variety, though it was not significantly different than eight other varieties. Although high yielding, ‘Coastal Star’ had a propensity to bolt, suggesting it would not be suitable for spring production in Georgia. The advanced selection ‘41-132’ was a high yielding variety with a low propensity to bolt making it more suitable for Georgia production. ‘81-47’, a green Batavian lettuce was the highest yielding leaf type, although it was not significantly different from nine other green and red types. ‘Louxal’ was a red leaf type that yielded well and had a low tendency to bolt. This study noted several varieties of lettuce that would be suitable for direct market production in Georgia. However head size for romaine varieties would need to be increased for sale on a wholesale market.

The Effect of Fertilizer Timing and Concentration on the Rate of Development of ‘Rex’ Lettuce Seedlings for Hydroponic Production

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Seeds of ‘Rex’ lettuce (Lactuca sativa) were sown into phenolic resin foam sheets and placed in flats in a polycarbonate greenhouse. The greenhouse temperature was maintained at 18 ± 2 °C. The seedlings were subirrigated with University of Arkansas standard greens fertilizer formulation at an electrical conductivity (EC) of either 0.5 dS/m or 1.0 dS/m beginning on 0, 3, 6, 9, 12, or 15 days after sowing. The seedlings were fertilized once a day and were additionally sub-irrigated with clear water once
Daily. Regression analysis was conducted to determine the effect of fertilizer concentration and timing on days to achieve the 1-leaf, 2-leaf, 4-leaf stage, shoot height, shoot fresh weight and number of leaves 4 weeks after sowing. The earlier the seedlings received fertilizer, the faster their rate of development and the fewer days required to reach transplant stage. The fewest number of days to reach the 1-leaf, 2-leaf, and 4-leaf stage were 11.6, 14.9 and 20.6, respectively, for fertilization beginning day 0 with an EC of 1.0 dS/m. The highest number of days to reach 1-leaf, 2-leaf, and 4-leaf stage were 17.7, 21.1, and 27.1, respectively, for fertilization beginning day 15 with an EC of 0.5 dS/m. The highest average shoot height and shoot fresh weight recorded was 7.2 cm and 1.8 g, respectively, for fertilization beginning day 0 with an EC of 1.0 dS/m. The lowest average shoot height and shoot weight recorded was 2.5 cm and 0.14 g, respectively, for fertilization beginning day 15 with an EC of 0.5 dS/m. The highest and lowest average number of leaves after 15 days were 7.8 and 3.4, respectively, for fertilization beginning day 0 with EC 1.0 dS/m and day 15 with an EC 0.5 dS/m.

The Long and Short of It: Sugarcane Planting Systems (Whole Stalks, Billets, and Single Nodes)

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The Louisiana sugarcane (Saccharum spp.) producers use stalk (vegetative) cuttings to plant 100,000 plus acres of their sugarcane crop rotation each year. Researchers with USDA-ARS, LSU AgCenter, American Sugar Cane League, private industry, and producers have conducted cooperative and independent research to determine the best methods to maximize sugarcane yields using various types of stalk cuttings (whole stalk, billets, and single nodal buds). Whole stalks (4 to 8 or more nodal buds) have been the typical planting method for the last 200 years. Healthy first year cane is harvested with a whole stalk harvester. The harvester cuts the stalks at the base and above the highest mature (hard) node. These whole stalks are then transferred to planting wagons where they will be either mechanical or manually planted. Billets are shorter stem pieces containing, typically, 2–4 nodes (buds). A slightly modified sugarcane combine harvester, where sets of cutting knives are removed, is used to harvest healthy, first year sugarcane into approximately 24 inch stem lengths (2–4 nodes) for “planting” billets. These billets are then mechanically planted. The use of single nodal buds for planting sugarcane is also under investigation. The single eye buds are cut from healthy first year cane, treated with protective chemicals, and then mechanically planted. Researchers are investigating the various planting systems (whole stalk, billets, and single nodal buds) and their interaction with various planting and cultural factors (row spacing, chemical treatments, fertility, planting rates, etc.). Research will continue to explore methods to reduce the disadvantages and maximize the advantages to these planting systems to adjust to the changing needs within the Louisiana sugarcane industry.

Timing and Cultivars for Fall Cilantro Plantings in Mississippi

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Cilantro is the fresh or dried leaf blades and petioles of the dual purpose plant Coriandrum sativum L., whose seeds are used as the spice known as coriander. We have been and are conducting a series of field and high tunnel trials to compare cultivars and planting times of cilantro with local markets in mind. Seed was sown at two planting dates in the open field at Verona and at one date into high tunnel raised beds at Crystal Springs Crops were irrigated as needed and hand harvested. Crops grew well at both locations and yields were very good. There were no significant differences in fresh yield within each location and planting date. At harvest, percent dry matter increased and plant height decreased from the first to second planting in Verona. Overall, it appears that Mississippi market growers can choose among several cultivars and production methods to raise a good crop of cilantro.

Vegetable Seedling Production with Sugarcane Bagasse Ash

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The eleven sugarcane mills in Louisiana processed 380,000 ac and 12.8 million tons of harvested sugarcane in 2014, producing 1.5 million tons of raw sugar, and an estimated 3 million tons of the fibrous plant residue called bagasse. Bagasse is the fibrous material remaining after removing the sugar, water, and other impurities from the sugarcane delivered to the mill. Typically, Louisiana sugarcane mills use a portion of the sugarcane bagasse for fuel producing over 22,500 tons of sugarcane bagasse ash as a by-product. Sugarcane mill owners, operators, and associated researchers have investigated and employed various uses for the sugarcane bagasse ash. Research was conducted to investigate the use of SBA as an amendment to soilless planting media for the production of vegetable seedlings. The ash was combined by...
volume with a commercial soilless growing media into 5 ratios (0:100, 25:75, 50:50, 75:25, and 100:0, sugarcane bagasse ash and growing media, respectively). Squash (Cucurbita pepo L.) var. ‘Straightneck’ and cantaloupe (Cucumis melo L.) var. ‘Magnum Hybrid Melon’ were planted in all of the 5 different planting mixtures with 4 replications and each experiment repeated twice. The results indicate that the addition of the ash enhanced squash and cantaloupe seedling growth, depending on the percentage of the ash added to the growth media. Squash plant stalk lengths and plant total fresh weights (stalk, leaves, tops, roots, and total plant) overall responded best at the 75% ash levels. Squash dry weights were consistently greater for all treatments where ash was added to the growth media compared to adding no ash. The 25% and 50% ash media produced the greatest cantaloupe leaf fresh weights. Cantaloupe leaf dry weights followed a similar trend, where the 25% and 50% ash media produced greater plant weights with lesser yields compared to the 75% and 100% ash media. This data suggests that the 75% and 25% ash growth media were suitable potting media combinations for squash and cantaloupe seedling production, respectively. Future research should investigate the addition of starter fertilizers to the sugarcane bagasse ash amended media to further enhance the growth of squash and cantaloupe seedlings. Additional plant species should also be evaluated for their response to sugarcane bagasse ash amended growth media.

Winter Organic Broccoli and Cauliflower under High Tunnels in Georgia

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High tunnel systems can reduce weather-related production risks and provide season extension opportunities. However, there is a lack of information about production practices for the Southeast region. We designed an experiment to evaluate broccoli and cauliflower over the fall-winter growing season under high tunnels located in a sub-tropical climate. The trial was a split-plot design with four replications. The main factor was planting date and the sub-factor was cultivar. Crop yields, quality, and days to harvest for each crop were evaluated. Environmental monitoring stations were placed in the high tunnel and adjacent field system at the project site (UGA Horticulture Research Farm, Watkinsville, GA). A mixed ANOVA model analyzed marketable yield data for each crop type. A logistic regression assessed the nonmarketable percentage of yield. The following results reflect the first year of data from an ongoing two-year study. The planting dates were 7 and 21 Oct. 2014. Black polypropylene landscape fabric was used as mulch and row covers were draped over the crops when nighttime temperatures were predicted to be ≤ 0°C. Planting date did not have an effect on the average marketable head weight among the broccoli cultivars evaluated (‘Imperial’, ‘Fiesta’, ‘Belstar’ and ‘Marathon’) or the cauliflower cultivars evaluated (‘Denali’, ‘Amazing’ and ‘Snowball Y’). However, the average marketable head weight of ‘Imperial’ was greater than ‘Marathon’ (P < 0.05) and for cauliflower ‘Denali’ was greater than ‘Amazing’ which was greater than ‘Snowball Y’ (P < 0.0001). Also, ‘Snowball Y’ had a greater percentage of non-marketable heads primarily related to riciness (< 0.005). The average daily air and soil temperatures were 3 °C and 4 °C greater in the high tunnels compared to the field, respectively (October to mid-February). On the coldest day of our season, the minimum air temperature was 9 °C greater in the high tunnels compared to the field (−3 °C and −12 °C, respectively).

Bitter Melon (Momordica charantia): A Potential New Crop for Texas to Reduce Risk from Diabetes

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Bitter melon (Momordica charantia) is a vegetable that is known in various Asian and South American countries because of the potential health promoting properties such as anti-diabetic properties. In the United States (U.S.), bitter melon is relatively unknown and usually only found in specialty markets. Considering the awareness of health benefits and an increasing trend of diabetes rates in the U.S., cultivation of bitter melon in the U.S. has tremendous potential as a specialty crop. In this study, five bitter melon cultivars were evaluated by growing in College Station, Texas. The performance of bitter melon was evaluated under field conditions for three years (2013–15). The yield of the first year of evaluation was comparable to other bitter melon growing regions and notably higher than the subsequent years of evaluation in College Station, Texas. Interestingly, the mandatory relocation of the field trial served to elucidate the importance of soil organic matter content in bitter melon production. Additionally, climatic variation amongst the evaluated trials also delineated the effect of temperature and precipitation in adequate bitter melon production. The quality of bitter melon was evaluated by the measurement of the levels of ascorbic acid in the all cultivars during three years of evaluation. The highest levels of total ascorbic acid were displayed in the Japanese Spindle cultivar (162.97 mg/100 g fresh fruit), while the lowest levels were expressed in the Hong Kong Green cultivar (42.69 mg/100g fresh fruit). The presence of ascorbic acid was confirmed by mass spectrometry. This study was supported by United States Department of Agriculture grant of “Designing Foods for Health through the Vegetable & Fruit Improvement Center 2010-34402-20875” and “State funding 2013-12177 VFIC-TX state appropriation”.

Stability of Dietary Nitrate in Vegetable Juices during Storage at Different Temperatures

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Dietary nitrate has been shown to be beneficial for health with benefits in cardiovascular health and sports performance. Con-
sumption of dietary nitrate is attributed to the production of nitric oxide via the nitrate-nitrite-nitric oxide pathway. Leafy greens, root vegetables and certain fruits are good sources of dietary nitrate. Juicing fruits and vegetables is one way of consuming these crops. Improper storage of fruit and vegetable juice may lead to the conversion of nitrate to nitrite, which could have negative effects. For example, in small infants nitrite could be detrimental to health and lead to methemoglobinemia. In the present study the stability of nitrate in arugula and beetroot was measured for one month stored at different temperatures. Fresh arugula and beetroot were juiced, and centrifuged to remove plant matrix and then stored at different temperatures such as 25 °C, 4 °C, –20 °C and –80 °C. The levels of nitrate were measured by reversed phase HPLC using C18 column. The initial levels of nitrate were found to be (4672.475992 ± 17 mg/L) and (3722.1 ± 43 mg/L) for arugula and beet, respectively. At room temperature nitrate degradation initiates within 24 hours, whereas at 4 °C both the juices start degrading to nitrite after 4 days. At –20 °C and –80 °C nitrate levels remain stable over a one month period. In conclusion it seems that arugula and beetroot juices required suitable temperature to prevent the degradation of nitrate. This study was supported by United States Department of Agriculture grant of “Designing Foods for Health through the Vegetable & Fruit Improvement Center 2010-34402-20875”.

**Implementing Marker-assisted Seedling Selection (MASS) in the University of Arkansas Peach and Nectarine Breeding Program**

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Despite the considerable genetic improvements fruit breeders have made over the past century, traditional seedling selection (TSS) is a time consuming, expensive, and laborious process. Fortunately, application of DNA-based information [marker-assisted selection (MAS)] is now a reality, and can provide peach breeders with more informed selection support to increased genetic gain per breeding cycle, improve selection efficiency, and significantly reduce breeding program operational costs. While marker-assisted parent selection (MAPS) has been achievable in peach and other Rosaceous fruit species, the use of markers for MASS is still in its infancy. However, recently several molecular markers for peach traits have been validated in the University of Arkansas (UA) peach breeding program for use in both MAPS and MASS. The logistical incorporation of these DNA tests through MASS into an already successful peach breeding program is underway. Five 2014 UA peach populations consisting of 298 F1 seedling were selected for testing MASS using two DNA tests: indelG (peach vs. nectarine); and PpCCD4b-SSR (white vs. yellow flesh). The F1 seedling genotypes for all five 2014 populations fit their expected parental segregation ratios patterns for both the indelG and PpCCD4b-SSR DNA tests, indicating that the markers were able to correctly discriminate all seedlings alleles. This work serves as a starting platform for the use of MASS in the UA program, which will continue to expand and evolve as additional DNA tests for the same or other breeding-relevant traits are developed and incorporated. Moreover, this case study, of the incorporation of MASS into an already successful traditional peach breeding program, highlights the feasibility and value of incorporating MASS into other Rosaceae tree fruit breeding programs.

**Response of Six Lamiaceae Ornamental Species to Saline Water Irrigation**

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Salt tolerance of six Lamiaceae ornamental species (Ajuga reptans ‘Burgundy Glow’, Lamium maculatum ‘Pink Pewter’, Perovskia atriplicifolia, Poliomintha longiflora, Scutellaria suffrutescens ‘Pink Skullcap’, and Stachys coccinea) was evaluated in a greenhouse experiment. Root cuttings were transplanted into 3.8-L pots and grown for three weeks in the greenhouse before treatment. Plants were then irrigated with nutrient solution at electrical conductivity (EC) of 1.2 dS·m⁻¹ (control) or saline solution at EC of 5.0 or 10.0 dS·m⁻¹ (EC 5 or EC 10) for six times, once a week. *Stachys coccinea* was the most salt tolerant among the six species/cultivars tested, with less than 50% foliar salt damage and 56% reduction of DW, and less than 10% reductions in gas exchange in EC 10 compared with control. *Perovskia atriplicifolia* (russian sage) and *Lamium maculatum* ‘Pink Pewter’ (spotted dead nettle) were the moderately tolerant with slight salt damage and low mortality rate in EC 10. With visual scores of 3.1 and 3.9, and DW reduction of 36% and 43% in EC 5, Russian sage and spotted dead nettle could perform well when irrigated with low quality water with EC less than 5.0 dS·m⁻¹. *Ajuga reptans* ‘Burgundy Glow’ (bugleweed), *Poliomintha longiflora* (mexican oregano), and *Scutellaria suffrutescens* ‘Pink Skullcap’ (cherry skullcap) were most sensitive to salinity stress and no plants survived in EC 10.
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Genotypic and Phenotypic Evaluations of Black Raspberry in North Carolina over Multiple Harvest Seasons

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The black raspberry industry in the United States has been stagnant in over 75 years, due to factors including lack of adapted, disease resistant cultivars and low variability of parental material and subsequent breeding populations. The discovery that black raspberry consumption can effectively combat some cancers has led to a resurgence of interest in black raspberry production and a renewal of breeding efforts. A multi-state effort, including North Carolina State University, has been gathering comprehensive phenotypic data and developing molecular tools to assist with future black raspberry improvement. Two half-sib populations, designated ORUS 4304 (192 progeny) and ORUS 4305 (115 progeny) that segregate for aphid resistance were planted in 2012 at the Sandhills Research Station in Jackson Springs, NC. Between Fall 2012 and Summer 2015, phenotypic measures of vigor, fruit quality and chemistry, and heat tolerance screening by chlorophyll fluorescence (North Carolina only) were determined. SAS 9.4 was used to perform PCA for variable reduction, standardization, and correlation analysis of the 133 measurements. Fruit traits such as berry and seed weights, and yield traits such as lateral length and node number generally clustered together in the same principal component and have positive correlation values ($R^2 > 0.60$). Those traits clustering together can be further analyzed with other locations’ data by ANOVA to determine genotype x environment interactions. Using single nucleotide polymorphism (SNP) and single sequence repeat (SSR) markers, a preliminary linkage map of 4304 was constructed with seven linkage groups, and aphid resistance was found on Rubus linkage group six in both populations. The finalized linkage map of 4304 will be validated against 4305 and existing red raspberry maps using SSR anchors. Phenotypic data will be used to identify QTL for traits of interest, particularly heat tolerance in NC and flower/fruit traits across all locations. Finally, selections made from 4304 and 4305 in North Carolina will be used as parents for black raspberry germplasm development in the future.

Assessment of Commercial Fruit Crop Potential of Selected Banana (Musa sp.) Cultivars in the Subtropics of Coastal Alabama

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In 2013, thirteen banana cultivars (Musa sp.) were planted at the Gulf Coast Research and Extension Center in Fairhope, AL, to determine the feasibility of producing banana fruit in this subtropical area. Banana cultivars were separated according to size (dwarf, medium, and tall) and planted to establish three separate experiments. Cultivars tested were ‘Double’, ‘Dwarf Cavendish’, ‘Dwarf Green’, ‘Dwarf Red’, and ‘Grand Nain’ (dwarf); ‘Cardaba’, ‘Gold Finger’, ‘Ice Cream’, ‘Raja Puri’, and ‘Yeinte Cohl’ (medium); ‘Pisang Ceylon’, ‘Saba’, and ‘Sweetheart’ (tall). Bananas were planted at an in-row spacing of 2.4 m and 3 m between rows. A completely randomized design with six single-plant replications was used. In 2015, two cultivars in both the dwarf and medium height categories produced mature bunches after anthesis. In the dwarf banana experiment, ‘Double’ and ‘Grand Nain’ flowered 160 and 175 days respectively after breaking of dormancy which was determined by the emission and full expansion of the first F10 leaf (width > 10 cm). ‘Double’ produced significantly heavier bunches (11.86 kg) than ‘Grand Nain’ (5.70 kg). They produced 8.7 and 8.3 hands per bunch, which resulted in 129 and 136 fingers, respectively, per bunch. In the medium height banana experiment, ‘Gold Finger’ plants needed a significantly longer period to flower (171) than ‘Cardaba’ (150). ‘Cardaba’ produced heavier bunches (7.2 kg) than ‘Gold Finger’ (5.6 kg). In the tall banana experiment ‘Sweetheart’ produced mature bunches after anthesis while ‘Pisang Ceylon’ flowered without reaching/completing bunch maturity. ‘Saba’ failed to flower. ‘Sweetheart’ produced more hands per bunch (8.6), fingers per bunch and (134) and fingers per hand (18) in comparison to ‘Pisang Ceylon’ (8.5, 117, and 16, respectively). Five of the 13 banana cultivars planted in the three studies flowered with sufficient time to produce mature bunches and therefore show promise in a banana production system in the climate of the Alabama gulf coast.

Nutrient Remediation using Two Plant Species in a Floating Treatment Wetland System

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Plant production in greenhouse and container nurseries typically generates runoff water with excess nutrients. Runoff water is either captured and reused for irrigation or flows into surface waters. Floating treatment wetland systems (FTWs) remove...
Determination of Nutrients Removed by Harvesting, Pruning, Thinning and Leaf Fall in Peach Trees

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Peach trees are often fertilized without considering nutrient removal by harvesting, pruning, thinning and leaf fall. Nevertheless, determining the amount of nutrients removed from trees through these practices is relevant for estimating how much should be restituted through fertilization. In this research study, 18 trees of six cultivars of different ripening seasons (early-season: ‘Desiree’ and ‘Spring Snow’; mid-season: ‘Sweet N Up’ and ‘Coralstar’; late-season: ‘Snow Gem’ and ‘SnowKing’) were selected, and the nutrients removed by pruning, thinning, harvesting and leaf fall were measured. The results from the first year show that early-season cultivars accumulated more nitrogen in thinned fruitlets and mature fruits, and more potassium in pruned wood, and harvested fruits than late-season cultivars. On the other hand, late-season cultivars accumulated more calcium in fruits than early-season cultivars. Leaf analyses did not reflect most of these changes as all concentrations were above the sufficiency levels (only leaf potassium concentration was found to be higher in leaves from early-season cultivars). Further research and more data are needed to evaluate the impact of different ripening season on peach nutrition but these results are expected to shed light on how to improve fertilization strategies for different peach cultivars.

Norman F. Childers MS Graduate Student Paper Competition

Phenology, Physiology, and Fruit Characteristics of Pierce’s Disease Resistant Vitis vinifera L. Selections in Alabama

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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 PD resistant V. vinifera selections developed at the University of California, Davis: ‘501-12’, ‘502-01’, and ‘502-10’ were planted in 2010 at
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the Chilton Research and Extension Center near Clanton, AL, to study their performance in central Alabama’s high PD pressure environment. No PD infection was detected during the period of plant establishment, thus detailed studies on the vines’ phenology, vegetative development, and cropping potential were initiated in 2015. Vine bud break, leaf emergence, and shoot development were recorded. Selections ‘502-10’ and ‘502-01’ started their development 2–4 days prior to ‘501-12’. All selections initiated bud break stage at the end of March, and the vines had fully developed canopies by 20 April. Selection ‘502-01’ had the earliest flowering season; however, all selections reached full flowering by 5 May. Selections differ in season of ripening. ‘502-10’ had an early ripening season and was harvested on 14 August, while the remaining two selections, ‘501-12’ and ‘502-01’, were harvested on 23 October and 30 October, respectively. All studied selections were highly productive with ‘502-10’ yielding 10.9 kg/vine, ‘502-01’ bearing 10.7 kg/vine, and ‘501-12’ producing 8.7 kg/vine. The selection with the smallest berries of 1.3 g and smallest clusters of 240 g was ‘501-12’, while ‘502-10’ produced the largest clusters of 467 g. The largest berries (2.9 g) belonged to ‘502-01’. Studies will continue to more completely evaluate these promising PD resistant V. vinifera selections, aiming to generate sound knowledge of vine phenology and development in central Alabama. Further development of viticultural practices to ensure optimal yield and fruit quality are necessary to define methods for sustainably producing V. vinifera in the southeastern United States.

The Effective Pollination Period of ‘AU Golden Sunshine’ (Actinidia chinensis) and ‘AU Fitzgerald’ (Actinidia delicosa)

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Kiwifruit size and marketability is closely associated with successful pollination. Commercial kiwifruit production often involves much effort to enhance pollination due to the inherent difficulties associated with functionally dioecious plants with flowers that do not produce nectar. Determining the length of time that female flowers can be successfully pollinated would aid management decisions. Therefore, the purpose of this research was to determine the effective pollination period (EPP) for Actinidia chinensis ‘AU Golden Sunshine’ and A. delicosa ‘AU Fitzgerald’. In 2013, 30 female flowers (n = 30) that had been previously isolated/bagged for each cultivar were hand pollinated each day by direct flower to flower contact with the male pollinizer, and re-bagged to prevent open pollination. ‘AU Golden Sunshine’ flowers were pollinated 1, 2, 3, 4, and 5 days after anthesis (DAA) and ‘AU Fitzgerald’ flowers were pollinated 1, 2, 3, 4, 5, and 6 DAA. Anthesis was considered the day the flower opened. In 2014 and 2015, the same procedures were followed as the year before but with slight modifications: 32 female flowers (n = 32) were hand pollinated with harvested male pollen each day with a camel hair brush and the flowers were pollinated for 1, 2, 3, 4, 5, 6, and 7 DAA. For all three years of the study, the EPP for ‘AU Golden Sunshine’ remained fairly consistent. In 2013, there was no decrease in fruit set, size or seed number over the 5-day period. In both 2014 and 2015, fruit set, size, and seed number declined at 6 and 7 DAA, suggesting that the EPP for this cultivar is 5 to 6 DAA. For ‘AU Fitzgerald’, the EPP was more variable. Fruit set, size, and seed number declined at 5 DAA for the first year (2013), suggesting that the EPP was 4 DAA. In the second year (2015) however, fruit set remained constant over the 7-day period with fruit size and seed number declining as DAA progressed. Flower production and fruit set was higher for ‘AU Fitzgerald’ in 2015, suggesting that the EPP was affected by the biennial nature of the species.

Aggregate Depth and Irrigation Frequency Affect ‘Rex’ Lettuce Development in a Shallow Aggregate Ebb-and-Flood Production System

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A novel soilless technique for the production of lettuce was tested to determine the viability of ornamental greenhouse growers adapting their ebb-and-flood irrigation benching to diversify into salad greens without having to purchase the conventional NFT or DFT hydroponic systems. The independent variables that affected the growth of lettuce were aggregate depth and irrigation frequency. Therefore, the experimental design was a three by four factorial, with three treatments for depth (19 mm, 38 mm, 57 mm) and four treatments for irrigation frequency (once every 1 h, 2 h, 4 h, 8 h), totaling twelve treatment combinations, each replicated three times in a randomized complete-block treatment design. ‘Rex’ lettuce seeds were planted in phenolic foam cubes, and sixteen plants were transplanted into each shallow-aggregate ebb-and-flood (SAEF) systems upon the emergence of four true leaves on each seedling. Shoot diameters and chlorophyll content were measured 42 days later, and shoots were harvested, weighed fresh, and then dried to acquire their dry weights. The treatment with 38 mm of aggregate irrigated every 2 hrs produced significantly higher average fresh and dry shoot weights than all other treatments: 343 g and 13 g, respectively. The treatments with 19 mm and 57 mm of aggregate irrigated every 8 h produced significantly lower average fresh and dry shoot weights than all other treatments: 343 g and 13 g, respectively. The treatments with 19 mm and 57 mm of aggregate irrigated every 8 h produced significantly lower average fresh and dry shoot weights than all other treatments as well as the lowest average shoot diameters. Chlorophyll content was significantly higher in the 57 mm treatment irrigated every 8hrs than in all other treatments, and the 19 mm treatments irrigated every 1hr and 2 h produced the lowest average chlorophyll content. Aggregate depth and irrigation frequency were demonstrated to significantly affect lettuce shoot diameter, chlorophyll content, as well as fresh and dry weight. The optimal treatment of 38mm aggregate depth irrigated every 2 h proved the viability of the SAEF system and its potential to produce uniformly marketable lettuce shoots reliably.

Planting Density, Harvest Stage, and Cultivar Affect Economic Return of Parthenocarpic
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Pickling Cucumber in a Once-over Mechanical Harvest System

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Parthenocarpic picking cucumbers are thought to be higher yielding than seeded types. Information regarding production of parthenocarpic picking cucumbers for mechanical harvest is limited. We evaluated the effect of plant density and harvesting time on yield and fruit quality for two commercially available varieties in the spring and summer of 2014 and 2015. In 2014, yield was highest at 80,000 plants per acre (PPA) but this density may be cost prohibitive. Yield was slightly lower at 40,000 PPA, but seed costs are cut in half, suggesting this rate is more economically feasible. Fruit quality was reduced in the third harvest but was unaffected by planting density. In 2015, we evaluated a broader range of plant densities and found that optimum densities differed by variety. Yield was again comparable from densities of 40,000 to 100,000 PPA. Harvesting time affected yield. An economic analysis will help solidify planting density and harvesting time recommendations.

A Comparison of Blueberry Cultivars in High Tunnel and Field Production

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This preliminary study investigated the effect of high tunnels on the production and growth of six blueberry cultivars under organic management. The experiment was conducted in 2015 at the Arkansas Agricultural Research and Extension Center in Fayetteville on a site that features Captina silt loam soil with a soil pH range of 5.0 to 5.5. The planting was established in 2009 and tested the cultivars Draper, Blue Crop, Aurora, Liberty, Chandler, and Ozark Blue in a randomized complete block design with four replications of each cultivar and 2 subsample plants per plot. A 9.1m x 14.6m movable skid high tunnel (HT) was placed over two blocks of the blueberry planting on 30 Jan. so that two replications of each cultivar were under the HT and two replications of each cultivar remained in the field. Both HT and field plots were pruned, fertilized, mulched, and irrigated. Domesticated bumblebee hives were placed in the HT on 15 Mar. to allow for pollination. The field had native pollinators and domesticated bees. The first blooms were on 24 Mar and 4 April for the HT and FD, respectively. ‘Draper’ was the first HT cv. to harvest on 29 May, and ‘Blue Crop’ was the first FD cv. to harvest on 29 May. On average the HT advanced cropping by 3 days, but cv. had a more significant effect on date of first harvest. Plants were harvested twice per week to measure yield per plant (g), average berry weight (g), and expressed berry juice (% Brix). Cane length (cm), leaf area (cm²) were measured, and specific leaf weight (cm² g⁻¹) calculated on 28 July. An ANOVA was conducted in JMP® v.9 using Student’s t-test to compare means. The yield per plant of ‘Liberty’ was significantly increased by the HT treatment, though no other cultivars showed a significant response to treatment (α = 0.05). The average berry size was significantly decreased within the HT for ‘Blue Crop’, ‘Chandler’, ‘Draper’, and ‘Liberty’ (α = 0.1). Berry % Brix, cane length, leaf area, and specific leaf weight were not significantly affected by treatment. It was hypothesized that yield and fruit size in the HT may have been pollination limited. Results indicate that the effect of HT on blueberry yield and growth are cultivar dependent and more research is needed into physiological effects of HT on blueberry plants before the technology could be recommended for grower adoption.

The Crape Myrtle Bark Scale: A New Threat for the No. 1 Flowering Shrub in the United States

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The crape myrtle bark scale (CMBS), Eriococcus lagerstroemiae Kuwana (Hemiptera: Eriococcidae), is an exotic pest on crape myrtle, Lagerstroemia spp. L., in the southeastern United States. Despite the severity of the damage to crape myrtle, there is a lack of information on the potential distribution of this scale across the United States. Survival under extreme temperatures is critical for the establishment and spread of exotic insects in subtropical and temperate regions. Understanding the effect of temperatures on the survival of E. lagerstroemiae can help predict not only the potential establishment but also CMBS population fluctuations over time. Therefore, the objective of this study was to evaluate the thermal tolerance of CMBS nymphs by measuring their lethal time leading to 50% mortality (L₅₀) at a set of low and high temperatures. Supercooling point (SCP), the temperature at which body fluids spontaneously freeze, was also used to measure cold tolerance. Results showed that mortality of nymphs increased at lower and higher temperatures and longer exposure times. The CMBS nymphs collected in July 2015 (summer), had high heat tolerance, with L₅₀ at 40, 45 and 48°C being 37.2, 8.7, and 1.3 h, respectively. However, the result of L₅₀ of summer nymphs exposed to cold temperatures was too low. Cold exposure experiments were then repeated every two months to determine the effects of cold acclimation to CMBS cold tolerance. Results indicate that L₅₀ and SCP increased with nymphs collected from July, 2015 (summer) to January, 2016 (winter). L₅₀ at 5 °C treatment temperature increased from 5.0 h in July, 2015 to 41.8 h in January, 2016. The SCFs in July, September, and November, 2015, and January, 2016 were –21.2 ± 1.5 °C (mean ± SE), –24.7 ± 1.7 °C, –25.5 ± 1.2 °C, and –26.6 ± 1.0 °C (F₀.₅₀ = 61.1, P < 0.0001), respectively. These results suggested that CMBS nymphs collected in January 2016, had the highest cold tolerance over the time period of sample collection. Results were used to fit a surface response curve of the relationship between nymphal survival to low temperature and exposure time. The model of this curve can be used to predict the population survival with the local temperature. The distribution of CMBS will be predicted based on heat tolerance measured in...
July 2015, and cold tolerance measured in January 2016. The prediction can be a reliable method to estimate the population survival and growth of this invasive pest under different climatic conditions.

**Fruit Section**

**The Effects of Shade on Greenhouse-grown Primocane Fruiting Blackberries**

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Primocane blackberry production in the upper south is limited by high temperatures during the bloom and early fruiting period, resulting in poor fruit set and poor fruit quality. Shade may have the potential to delay bloom and flowering to a more favorable season by reducing temperatures that cause poor fruit set and quality. A greenhouse study was established to evaluate the effects of shade on primocane blackberry growth, physiology, and fruiting in a controlled greenhouse environment. Canes of ‘PrimeArk® 45’ were planted in 12 L pots. At approximately 0.25 m tall, one of the four following treatments was imposed with eleven single plant replications: 1) an untreated control (CK); 2) unshaded for 30 days then shaded for 30 days (US); 3) shaded for 30 days then shaded for 30 days (SS); and 4) shaded for 30 days and unshaded for 30 days (SU). After treatments ended, plants were grown without shade for 30 days. Plants in the SU treatment were significantly taller than the US while the control and SS treatments were intermediate. A similar trend was seen between the height and cane diameter with the SU treatment as the highest and US as the lowest. The SU had the highest total leaf area of all treatments and CK was the lowest. Dry weight of leaves was consistent for all treatments except for SS which was significantly lower than the others. Shading reduced net photosynthesis measured, but plants readjusted to unshaded conditions. First bloom dates for each treatment was recorded. The CK bloomed first followed by US and SS. The last to bloom was the SU, 26 days after the CK. The US displayed nearly four times as many flowers as the SS, CK, and SU when all potted plants were harvested. In conclusion, there was a delay of ‘PrimeArk-45’ flower formation when 50% shade cloth was implemented and removed in the SU treatment.

**The Effects of Water Management Strategies on Citrus Growth and Yield**

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Texas grapefruit production is primarily concentrated in the Lower Rio Grande Valley (LRGV) in close proximity to Mexico. The subtropical climate conditions are ideal for citrus production, but present many unique challenges due to water shortages and pest pressure. Developing management strategies to manage root weevils (*Diaprepes abbreviatus*), *Phytophthora* spp., and water stress has proved difficult in recent years. However, experimentation with plastic mulch groundcover has yielded promising results in weevil control and soil moisture retention. Plastic mulch groundcover in conjunction with raised bed plantings in citrus has improved the soil environment by increasing soil temperatures and moisture deeper in the soil profile; effectively increasing tree growth. When compared to the traditional planting strategy of flat-bed production without groundcover, we found that this novel strategy increased plant height, trunk diameter and canopy circumference. In consecutive years, we have also found that groundcover increased yield. However, seasonal changes in temperature and rainfall have resulted in variability of fruit size and load.

**Tunnel-in-Tunnel Effects on ‘Natchez’ Blackberry: Promise and Problems**


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Research into the effect of HT on ‘Natchez’ blackberry has been conducted at the Arkansas Agricultural Research and Extension Center in Fayetteville from 2013 to 2015. High tunnels were modified with a tunnel-in-tunnel (TNT) to increase heat unit accumulation and further advance development and cropping of florican blackberries. Initial results were mixed and have been inconclusive. A TNT is a tunnel structure covered in polyethylene plastic film inside a HT that encloses the planting and serves to further modify the plant environment. The TNT has shown the ability to advance the flowering and fruiting of ‘Natchez’ blackberry earlier in the season, but has led to a decrease in yield compared to the high tunnel (HT). In 2015 the HT and TNT treatments were implemented on 3 Feb. with bumblebees placed in both treatments on 9 Mar. In 2015 the TNT advanced ‘Natchez’ bloom by 7 days compared to the HT and 19 days compared to the field. The date of first harvest for both TNT and HT was advanced 17 days compared to field production. Fruit were harvested twice per week. Total yield per plot (g), marketable harvest (g), average berry weight (g), and berry brix were recorded and data analyzed in SAS® using PROC GLM at \(\alpha = 0.05\). The TNT treatment had significantly lower total yield than the field while the HT alone had significantly greater total yield. Average berry weight was significantly reduced within the TNT compared to the HT. Both HT and TNT treatments resulted in a similar percent marketable yield, which were significantly greater than the percent marketable yield from the field treatment. A preliminary bumblebee study was conducted to determine if the TNT environment has an effect on bumblebee activity. Results from this preliminary study show a significant decrease in flower visits by bees at 1500–1600hrs in the TNT compared to the HT. Also there were significantly fewer bees exiting and entering the hive during the 1200–1300hrs and 1500–1600hrs time intervals in the TNT compared to the HT. This leads to
the idea that the TNT treatment may have a negative effect on pollination of blackberry by bumblebees. Further study is needed to corroborate this preliminary data and to determine the specific environmental conditions of the TNT that are affecting bee activity or leading to reduced berry size and yield.

**Application of Marker-Assisted Breeding in the University of Arkansas Peach (Prunus persica (L.) Batsch) Breeding Program Targeting the Major Locus for Fruit Acidity**

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Peach (Prunus persica (L.) Batsch) is the third-most important temperate tree fruit crop produced in the world. It is a diploid species that belongs to the Rosaceae family. Fruit quality characteristics such as flavor, acidity, color, flesh texture, size, shape, and shelf life are important attributes on which breeding programs focus to produce new and improved peach cultivars. The Arkansas peach and nectarine breeding program began in 1964 and was initially focused on clingstone, non-melting, yellow-flesh peach cultivars destined for the baby food industry. In recent years, the objectives of the program have changed to breeding fresh-market cultivars with different textures, flavors, flesh and skin colors, and harvest dates. Fruit acidity evaluated in the field and measured as titratable acidity (TA) is an important component of flavor and within the Arkansas peach breeding program a wide range of TA levels is present. As part of the RosBREED project, phenotypic and genotypic data were collected on numerous seedlings, selections, and cultivars in 2011, 2012, 2013, and 2014 with the objective of implementing marker-assisted breeding (MAB) for this trait to complement the traditional breeding process. The simple sequence repeat (SSR) marker CPPCT040, located on the chromosomal region in which the D-locus/gene (which segregates for low and high acidity peaches) is found was screened. This DNA test was able to distinguish homozygous (DD) and heterozygous (Dd) low-acid individuals and homozygous (dd) high-acid individuals. These results are promising and provide the basis for the application of MAB for TA in this traditional breeding program in the form of marker-assisted parent selection (MAPS) or marker-assisted seedling selection (MASS).

**Consumer Attitudes Toward Genetic Engineering in Muscadine Grapes**

Anna Edenbrandt¹, L. House², M. Olmstead*,³, Z. Gao¹, and D. Gray⁵

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Muscadine grapes (Vitis rotundifolia Michx.) are native to the southeastern United States, and a majority of the fruit is sold for wine production or fresh consumption. Unlike many table grapes sold for fresh consumption, muscadine grapes are seeded, have thick skins, and a limited shelf life due to a number of postharvest rots. Precision breeding via cisgenic technology has resulted in grapes with improved disease resistance; however, it is unknown if consumers would accept these or be willing to pay a premium price for either seedless or disease-resistant Muscadine grapes. The objective of this study was to determine if consumers were able to distinguish between different breeding technologies and to determine if Muscadine consumers were different than general grape consumers and thus more accepting of the technology used to produce seedless, disease-resistant grapes. In 2013, a focus group directed survey development, avoiding negative “triggers,” and a nationwide survey deployed including Muscadine and non-muscadine grape consumers (n = 2428). The choice experiment survey examined production method, seed type, and price. In addition, respondents were given different definitions of the breeding method to determine the impact of information on acceptance. In all cases, respondents were more likely to pick a grape if the price was lower, and were also willing to pay more for seedless grapes than large seeds. Survey respondents preferred traditionally produced grapes, despite understanding the difference between transgenic and cisgenic methods. Muscadine grape consumers tolerated the presence of large seeds, despite preferring seedless and were reluctant to choose not purchasing grapes at all. There was no significant difference for willingness to pay between transgenic and cisgenic; however, the willingness to pay was significantly smaller, for those respondents that received long definitions. This underlines the impact that knowledge has to help consumers make informed decisions regarding biotechnology. Finally, non-Muscadine and Muscadine consumers were willing to pay more for cisgenic or transgenic seedless grapes vs. those that were traditionally bred with large seeds. Overall, this suggests that consumers are more accepting of cisgenic than transgenic, but not to the point that it is a preferred method.

**Evaluation of Selected Fire Blight (Erwinia amylovora) Resistant Apple Rootstocks for Alabama**

Elina Coneva*¹ and James Pitts²

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Fire blight caused by a bacterium Erwinia amylovora is a major disease in apple production, especially in the southeastern region. An apple rootstock study was established at the Chilton Research and Extension Center near Clanton, AL, in 2014 in order to evaluate 14 newly developed fire blight resistant size-controlling rootstocks grafted to ‘Aztec Fuji’ apple. Rootstocks
Evaluation of Three Table Grape Cultivars under High Tunnel and Three Training Systems

M. Elena Garcia¹, D.T. Johnson², D.A. Dickey³, and S. Alman¹

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The sustainability of grape production can be improved by advancing and extending the harvest season to capture high-value markets and by reducing pesticide inputs to improve environmental sustainability. By utilizing high tunnel (HT) technologies and applying them to grape production, there is an opportunity to increase grape production in geographic regions where climatic conditions can be limiting and a large number of pesticide applications are necessary. In 2011, a planting of the cultivars Faith, Hope, and Mars was established in a Quonset-style Haygrove Supper Solo HT to investigate the performance of table grape cultivars under HT and field conditions at Fayetteville, AR. The trellis system was Geneva double curtain (GDC). This study was terminated in 2013 and a new planting was established in 2014. The cultivars in this new trial are Faith, Gratitude, and Jupiter. Two modified double high cordon systems trellises were established, one on the east side and one on the west side of the tunnel. A GDC trellis was positioned in the middle of the tunnel. Results from both the 2011 and 2014 plantings indicate great potential for table grape production under HT. Compared to field plantings, the vines in the HT were precocious (fruiting one year after planting), yield and berry quality was higher, and pesticide applications were decreased. In 2013, fruit was harvested from the HT planting, but not from the field due to below freezing temperatures in March and April. Yield for the red cultivars Faith and Mars was 43.6, 34.7 kg/plant respectively. The white table grape cultivar, Hope yielded 36.8 kg/plant. Although, there were no significant differences for training system or cultivar for yield, average yield/vine was substantial for the 2014 planting in 2015 (Faith = 11.0 kg, Jupiter and Gratitude = 10.0 kg each). Compared to field production where 8 to 10 fungicides and four to five insecticide applications were necessary to maintain plant health, berry yield and quality, only two fungicides and two insecticide applications were made to the HT grapes. These studies have demonstrated that HT improve the environmental sustainability of table grape production in our region.

Golden Kiwifruit, Actinidia chinensis,
Evaluation at SFA Gardens and Opportunities for Commercialization

David Creech*
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While both green kiwifruit (Actinidia delicosa) and golden kiwifruit (A. chinensis) vines grow in Texas, they rarely produce fruit. As part of a trialing agreement, SFA Gardens received vines in November, 2010 from Dr. Jay Spiers, Auburn University, Alabama. Three female varieties, ‘AU Golden Dragon’, ‘AU Golden Sunshine’, and ‘Au Fitzgerald’ were coupled with three males ‘CK3’, ‘Tiger’, and ‘AU Arthur’, respectively. Vines were planted in January 2011, in a full sun location with two female plants per male. The leaf canopy area occupied by a single row of eight ‘Golden Dragon’ vines and five ‘CK3’ vines was 880 square feet. First production in September 2014, resulted in 144 lbs (65 kg) of kiwifruit from eight vines of ‘Golden Dragon’, with much lesser production from the other two female varieties, ‘AU Golden Sunshine’, and ‘Au Fitzgerald’. In September 2015, 875 lbs (397 kg) of ‘Golden Dragon’ kiwifruit were harvested from the eight vines. The small plot results in this non-replicated trial results in an extrapolated production of approximately 20 tons per acre. Consumer acceptance was excellent. In September 2015, 63 participants were given a bag of kiwifruit and a survey form. On a 0–10 scale (with 0 = inedible and 10 = excellent), the crop averaged 8.84. Comments included that respondents appreciated the golden color, a surprise to most familiar only with green kiwifruit. Participants noted a very fast ripening rate and fruit needed refrigeration to maintain quality. Fruit allowed to over ripen at room temperature were sour. About two-thirds reported eating the skin was fine. While two crops in a row from this very small plot is highly preliminary, there is reason for optimism. The superior ‘Golden Dragon’ production is most likely attributed to the heavy flowering of the male, ‘CK3’. The other male pollinators ‘Tiger’ and ‘Arthur’ have performed poorly with some suffering from dieback, sometimes to the ground, usually followed by new vigorous shoots sprouting from the base, a malady still undiagnosed. Future trials are planned with plots at Texas A&M University, Stephen F. Austin State University, and with cooperating farmers.

Growing Strawberries in High Tunnels: Five Years of Lessons Learned

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In the early 1970s, a partnership was formed with the University of Arkansas and the Arkansas Strawberry Association to study growing strawberries in high tunnels. The University of Arkansas has high tunnel facilities at the Fayetteville Demonstration Farm in Northwest Arkansas. Since 2006, Dr. Scott McClure and his colleagues have been working with the strawberry industry to improve strawberry production in high tunnels. This work has resulted in significant improvements in yields, disease, and pest management of strawberries grown in high tunnels. This paper presents a summary of the progress made over the past five years, including the development of new varieties, cultural practices, and pest management strategies. It also discusses the challenges and opportunities for growing strawberries in high tunnels.
The fresh strawberry market in Arkansas is limited to the months of April and May. There is great potential to expand local markets to meet the growing demand for locally produced strawberries. In 2010, we started a series of research projects to determine the feasibility for off-season strawberry production utilizing high tunnel (HT) technologies. During the 2010–11 and 2011–12 seasons, following plasticulture recommendations, cultivar trials were established at Fayetteville (USDA Hardiness zone 6b) and Hope (USDA Hardiness zone 8a) to determine cultivar performance. Fayetteville plantings included the cultivars Albinon, Elyana, Radiance, and St. Festival. At Hope, ‘Albion’, ‘Elyana’, ‘Camino Real’, ‘Radiance’, and ‘St. Festival’ were tested. Two planting dates (late September and early October) were selected based on industry recommendations. For both years, fruit harvest began at the end of November in Fayetteville and at the end of October in Hope. Yield was significantly affected by planting date, with the late September planting having the higher yields. At Fayetteville, ‘Albion’ had the highest yields both years, with significant differences in yield compared to the other cultivars. In Hope, ‘Albion’ had lower yields than all cultivars except Elyana though the difference was only significant with ‘Radiance’. ‘Radiance’ had significantly higher yields than all other cultivars. Although ‘Radiance’ had higher yields in Hope, and ‘Albion’ had the highest yields in Fayetteville, they both had considerable pest problems. Although ‘St. Festival’ did not have the highest yields at either location, it was rated the best performer at both locations because of its lower pest susceptibility, consistent production, and berry quality. During the 2013–14 season, a nutrient management study was initiated to determine the response of the St. Festival strawberry cultivar to different nitrogen (N) fertilizer rates in order to develop a fertilization program for strawberries grown under HT production systems. Results indicated no response from this cultivar to the different N fertilizer treatments under our soil conditions. These studies have demonstrated that for most years, off-season strawberry production is a feasible alternative for local market sales.

Method to Measure Drought Tolerance of Rabbitsand (Vaccinium ashei) and Southern Highbush (Vaccinium corymbosum X) Blueberry Cultivars

Donna Marshall-Shaw*, Stephen Stringer, and Hamidou Sakhanokho

Thad Cochran Southern Horticultural Laboratory, USDA-ARS, Poplarville, MS 39470

In an effort to more efficiently phenotype blueberry seedling for the breeding program, a method to measure drought tolerance in Rabbitsand and Southern Highbush blueberry cultivars is being developed. Proline is accumulated in many plants in response to biotic and abiotic stresses, and seems to have a protective role in the adaptation of the plant cells to water deprivation. Plants of Rabbitsand and Southern Highbush blueberries were held without water for up to 50 d. Leaf samples collected every 1–3 d revealed a marked increase in Proline within 10 d of water deprivation. Levels then reduced, but never returned to saturation levels. Cultivars that had higher Proline peaks also had a shorter endurance to the water deprivation. ‘Georgia Gem’ had the least pronounced Proline spike yet lasted for 50 d with no water.

Phenotypic and Molecular Analysis of Black Raspberry Plant and Fruit Traits in the Southern United States

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Over the last 75 years, the black raspberry industry in the United States has not grown, and breeding has been hindered due to a lack of elite germplasm and adapted, disease resistant cultivars. Recent publications in the popular press extolling the health benefits of a diet rich in polyphenolics, and black raspberries in particular, has led to a resurgence of interest in the production of this fruit and a renewal of breeding efforts. A multi-state effort, including North Carolina, is in place to take comprehensive phenotypic data and develop molecular tools to assist with future black raspberry improvement. Two half-sib populations, designated ORUS 4304 (192 progeny) and ORUS 4305 (115 progeny) that segregate for aphid resistance were planted in 2012 at the Sandhills Research Station in Jackson Springs, NC and 10 other locations in Oregon, New York, and Ohio. Between Fall 2012 and Summer 2015, phenotypic measures of vigor, fruit quality and chemistry, and heat tolerance (North Carolina only) were evaluated. In North Carolina, floricane and primocane vigor correlated positively with biomass and negatively with winter damage (P < 0.0001). The interval between flowering date and fruiting date was not different between population, year, or location, except for North Carolina, where the interval was 27 days versus 36 days. Average flowering interval was not different between 4304 and 4305, however 4304 flowered and fruited over a longer period of time, which could have implications for a machine harvest versus hand pick operation. In North Carolina, we saw a decline in plant vigor and increased winter damage by season three. The decline could be attributed to several factors making production difficult in the Southeast, including high day and night temperatures, drought conditions, and latent viruses. However, based on phenotypic data collected over the 3 years in North Carolina, three individuals were selected that had heat tolerance, fruit quality, and high vigor. These individuals will be used in future breeding efforts as parental material. In addition, molecular and genomic tools developed in Oregon and North Carolina will be used to screen future black raspberry and red raspberry populations.
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Part 1: Colloquia and Workshops

Colloquium

Monday, August 8, 2016

Farms of the Future: Controlled Environment Agriculture (CEU Approved)

Sponsor: Floriculture (FLOR)
Coordinator: Chris Currey
Iowa State University, Ames, IA

Food crop production in protected environments increased by 44% between 1999 and 2014, and the landscape of commercial greenhouse production is changing. The aims of this colloquium are to discuss how greenhouse production is changing and what types of food crops are being produced in greenhouses and controlled environments, including transitioning into food crop production, organic production, strawberry production, mushroom production, and aquaponic production systems. This colloquium will complement last year’s colloquium on vertical farming, but it will be expanded to discuss the crops and production systems that are relevant to non-ornamental horticulturists interested in greenhouse and controlled-environment crop production.

9:00–9:05 AM
Introduction
Chris Currey*
Iowa State University, Ames, IA

9:05–9:40 AM
Resource Use Efficiency in Controlled Environment Agriculture
Marc van Iersel*
University of Georgia, Athens, GA

9:40–10:15 AM
Controlled Environments for Production of Value-added Food Crops and Transplants
Chieri Kubota*
The University of Arizona, Tucson, AZ, USA

10:15–10:50 AM
Improving Efficiency, Reducing Risk: Making Sense of Uncontrolled Environments
John Lea-Cox*
University of Maryland, College Park, MD

10:50–11:25 AM
Thinking Sociologically about Controlled Environment Agriculture: Challenges and Opportunities
Michael Carolan*
Colorado State University

11:25 AM–12:00 PM
Discussion

* An asterisk (*) in front of a name indicates the presenting author.
Special Symposium—Mysteries of the Voynich Codex: A Mesoamerican Herbal

Sponsor: History of Horticultural Science Working Group
Moderator/Coordinator: Jules Janick
Purdue University, West Lafayette, IN

Objectives: The Voynich Codex is a bizarre manuscript that has defied decipherment. The symposium/workshop will review the historical, botanical, zoological, and iconographic evidence related to the Voynich Codex.

Description: The symposium will review the bizarre Voynich Codex, discovered in 1912 in Italy by the Polish book dealer Wilfrid Voynich (1965-1930), which has eluded decipherment despite repeated attempts by world-renowned cryptologists. The profusely illustrated manuscript is mostly an herbal, but also contains numerous illustrations of hundreds of nude nymphs cavorting in pools connected by strange vascular systems; various magic circles consisting of astronomical images as well as a zodiac with many New World animals as signs; and various pages of text that appear to be medical prescriptions. The style of the plant illustrations is similar to the 1552 Codex Cruz-Badianus written by indigenous Indians trained in the College of Santa Cruz, which was established for Aztec nobility. Of the 309 plants or plant parts illustrated, 59 representing 55 species (17% of the total) have been identified as indigenous to Mesoamerica. Of 16 animal species identified, 14 are indigenous and 2 are species introduced by the Spanish (cattle and sheep). One mineral crystal identified (boleite) is only found in any quality and quantity in Mesoamerica. The text, written in an unknown alphabet or syllabary in an unknown language, has been partially deciphered based on labels connected to many of the plants. A map based on Kabbalah imagery identified the New City of Jerusalem (Puebla de los Angeles) founded by Fray Toribio de Benavente Motolinía, one of the 12 priests who accompanied Cortes to Nueva España. The main text, however, defies decipherment and seems to be in an extinct language related to Nahuatl from central Mexico since there are many Classical Nahuatl cognates. We surmise the author of the Voynich manuscript might be one of the sons of Aztec nobility trained in colleges by the Franciscan friars. The manuscript is dated based on internal evidence to 1565. The symposium/workshop will review the historical, botanical, zoological, and iconographic evidence related to the Voynich Codex. We believe the complete translation will demonstrate that this Aztec manuscript is one of the most valuable historic texts of the 16th century since it was not filtered through Spanish or Inquisition censors.

Welcome and Introduction to the Voynich Codex
Jules Janick*
Purdue University, West Lafayette, IN

New Spain in the 16th Century
Fernando Moreira*
University of Calgary, Calgary, AB, Canada

Identification of Plants: The Rosetta Stone
Arthur Tucker*
Delaware State University, Dover, DE

Identification of Animals
Elizabeth A. Flaherty*
Purdue University, West Lafayette, IN

Iconography: Nymphs and Magic Circles
Jules Janick*
Purdue University, West Lafayette, IN

Workshop—From Farm to Pharmacy
Sponsor: Herbs, Spices, & Medicinal Plants Working Group
Moderator: Nirmal Joshee
Fort Valley State University, Fort Valley, GA
Coordinator: Hideka Kobayashi
Kentucky State University, College of Agriculture, Food Science, and Sustainable Systems, Frankfort, KY

Objectives: 1) Update the knowledge base for scientists, industry leaders and laypersons in the area of herb, spice, and medicinal plants. 2) Provide interaction and networking opportunities for scientists in different disciplines, including ethnobotany, food science, pharmacognosy, biotechnology, and horticulture science and others in this area.

Description: The workshop will provide the premier interdisciplinary and multidisciplinary forum for researchers and educators to present and discuss the recent innovations, trends, and opportunities in the field of Herbs, Spices, and Medicinal Plants. Several focus areas for the workshop have been identified such as with ethnobotany and indigenous medicine, cultivation, harvesting and quality control, extraction and isolation of phytochemical constituents, drug discovery and finally commercialization.

Short Rotation Paulownia Tree As a Multipurpose Medicinal Plant
Nirmal Joshee*
Fort Valley State University, Fort Valley, GA

Separation and Identification of Bioactive Components
Agnes Rimando*
USDA-ARS, University, MS

An asterisk (*) in front of a name indicates the presenting author.
Separation and identification of compounds are integral parts of many research endeavors including evaluating effects of growth conditions on bioactive components, determining biosynthetic pathways, distinguishing sample origin(s), determining contamination, etc. Separation of bioactive compounds invariably employs either liquid chromatography or gas chromatography, when the analyte is non-volatile and/or does not have chromophore. Identification can be simple when the target compounds are known, but could be more involved and tedious when handling unknown compounds. For identification of unknown compounds, an “activity-guided” approach may be pursued. Identification of compound involves the use of various spectroscopic methods, typically, UV, IR, MS, and NMR. General methods and principles in separation and identification of plant products of secondary metabolism will be covered in this presentation.

1:30–1:45 PM  
**Medicinal Plants of the Highland Maya of Chiapas, Mexico, and Ethnobotanical Gardens**  
Paul Duncan*  
University of Georgia, Athens, GA

1:45–2:00 PM  
**Cultivation of Chinese Medicinal Plants in Minnesota: Challenges and Perspective**  
Changbin Chen*  
University of Minnesota, St. Paul, MN

2:00–2:15 PM  
**Harvesting and Quality Control of Organically Grown Medicinal Plants**  
Xiaozhong Liu*  
Amway, Buena Park

2:15–2:30 PM  
**Medical Ethnobotany and the Discovery of New Drugs for Antibiotic Resistant Infections**  
Cassandra Quave*  
Emory University, Atlanta, GA

Rates of multidrug resistant bacterial infections in both the community and healthcare setting are on the rise, making certain drug resistant pathogens a top public health concern. Nevertheless, the number of new antibiotic leads in the pipeline is diminishing, and many scientists have put out a call for the discovery and development of new classes of drugs that could mediate microbial pathogenicity rather than growth and survival. One example of this is the staphylococcal quorum-sensing pathway, controlled by the accessory gene regulator (agr) system, which as a global regulator of staphylococcal virulence. Likewise, other pathogenesis factors such as microbial biofilms, which confer a state of intrinsic resistance in infections, are recognized as high value targets in drug discovery initiatives. Thus, while the scientific community has established new targets for screening efforts, the question of where to find the best drug candidates remains. Our laboratory takes an ethnobotanical approach to drug discovery. We focus our screening efforts on those medicinal plants used in traditional medicine for the treatment of infectious disease. Here, I will discuss how we employ methods from medical ethnobotany to identify, extract and study medicinal plants in effort to discover and develop the next generation of anti-infective drugs for antibiotic resistant infections.

(CEU Approved)  
**Workshop—Seize Your Future Internationally: New Opportunities in Horticultural Consulting**  
Sponsor: International Horticultural Consultants Working Group  
Moderator/Coordinator: Roland Ebel  
Autonomous University of the State of Mexico, Toluca, Mexico  
Coordinator: Clinton Shock  
Oregon State University, Ontario, OR

**Objectives:** Advise about new opportunities in international horticultural consulting.

**Description:** The world is evolving: political changes, especially in Asia, are diversifying the horticultural landscape, creating new economic contexts (broadening the number of producer countries and potential consumer markets), as well as introducing innovative crops and challenging production conditions. New horticultural markets represent exciting consulting opportunities all over the world for experts and well-prepared alumni. To succeed in these new markets, expertise is as important as cultural openness and flexibility. This workshop and the following discussion seek to present the most promising countries regarding emerging horticultural consulting and offer the opportunity for potential consultants to receive advice from experts closely connected to these countries.

1:00–1:20 PM  
**Emerging Horticultural Research and Education Opportunities in Myanmar**  
Tim Davis*  
Texas A&M University, College Station, TX  
Eric M. Bost  
Texas A&M University, College Station, TX

The Republic of the Union of Myanmar (also known as Burma) has been undergoing political transformation in recent years that has opened up new opportunities for agricultural development. Agriculture is an important component of the country’s economy and horticultural production has good potential. The country is relatively rich in natural resources (e.g. water) that could support diverse horticultural crop production. Precipitation is relatively abundant but seasonal, and much of the country is frost-free. Nonetheless, horticultural crop yields in the country are generally well below world averages. Despite its significant agricultural economy, Myanmar has only one agricultural university and the supply of well-qualified gradu-
Horticulture in Iran: Unique Potentials and Challenges
Esmaeil Fallahi*
University of Idaho Parma REC, Parma, ID

The art and science of horticulture and horticultural crops are integral parts of Iranian’s rich and ancient culture and modern economy. Many deciduous fruit, flowers, and vegetables are native to Iran, and from there, they were distributed to the rest of the world through the Silk Road established by the Achemenian Dynasty. Variations in climate and presence of numerous mountains, lakes, rivers, and natural springs have created a unique country capable of producing all types of fruit, vegetables, and flowers. Apples and other fruit are commercially produced in mountain ranges of Alborz and Zagrous and in many central provinces of Iran. The Caspian Sea area in the north of Iran, one of the most unique regions in the world where mild Mediterranean climate merges with the adjacent Alborz mountain ranges, has created a home to numerous species of edible horticultural plants, ranging from tea to cherries and pomegranates. Pistachio, olive, citrus, banana, and date are produced in Kerman, Fars, and Khuzestan regions. However, the Iranian horticultural industry faces many challenges, including global and regional political issues. Although some attempt has been made to preserve invaluable germplasm, a large number of native fruit, vegetables, and flowers are becoming extinct. Postharvest transportation and storage of horticultural crops are some of the most important issues Iranian horticulture has to face. The future of horticulture in Iran can likely be bright, particularly if peace prevails in the region. Horticultural products have the potential to replace the oil income after reserves disappear. Recent political changes have opened the doors to numerous horticultural business and consulting opportunities with Iranian scientists, private sectors, consultants, and distributors. However, all these activities need to be conducted within the law framework in order to prevent any international dispute or introduction of exotic pest and diseases.

Improving the Value of Farm Produce and Income of Growers in Southeast Asia, India, Nepal, Kenya, and the Central American Countries
Juan Diaz-Perez
University of Georgia, Tifton, GA

Growing food crops (such as fruits and leafy vegetables) requires special attention during pre- and postharvest so as to minimize losses, increase yield, and maintain quality. This is a challenge if hot and humid weather and poor transportation systems prevail. It is possible to increase the farm families’ income by simply practicing appropriate techniques during production, harvesting, and marketing. However, most of the growers get information about technologies from pesticide vendors/agents who advocate their product even for non-biotic issues, including nutrient and water management, pH, salinity, temperature, stress, etc. This has caused additional loss of yield, low income, non-sustainable food production systems, and pollution. There is an urgent need to extend professional advisory services for a whole range of crops, from production to marketing. Improved pre- and postharvest management (reduce field heat, cooling, etc.) could reduce produce water loss and respiration, while increasing the fresh mass and quality (freshness) of produce with extended shelf-life at the consumer end. Activities such as cleaning, sorting, grading, and packaging of fresh farm produce are also important to minimize losses and increase farm income. In South East Asia, India, Nepal, Kenya, and the Central American countries, farms are generally family-owned and operate with less than one hectare of land. Their livelihood solely depends on farming with intensive cropping systems. Therefore, a well-planned comprehensive program needs to be introduced to improve the production system. This presentation is on a range of cultural practices, including land preparation, liming, nutrient and water management, soil and soilless substrate formulation, transplant establishment, mulching, cropping systems, use of pesticides and integrated pest management, harvesting, postharvest technology, and shipping of produce practiced by the growers.

Working in Afghanistan and Pakistan’s Agricultural Industries
Louise Ferguson*
University of California, Davis, Davis, CA

Agricultural consulting in Afghanistan and Pakistan reflects their histories. Colonized by England, educated Pakistan speaks English and has familiar government, education, and commercial systems. Afghanistan has never been colonized. For both, opportunities are primarily through USAID or NGOs, often postconflict and in the form of project proposals. Commercial opportunities are less common. Compensation is determined by the funding body. For both countries, visas, with letters of introduction, local facilitators, translators, drivers, security, and local contacts are necessary to work. With most projects, the final objectives are to develop better technical information, local capacity, information outreach, profitable production, and enter higher value export markets. Both countries have university agricultural departments and extension services, but the former are disconnected and the latter lack techni-
cal training. The level of knowledge is very basic although more advanced Pakistani companies have entered export markets. Your role will be to assess a situation, determine what can be done within the situation, or with contacts you facilitate, and how to do it. Two ongoing programs will be presented; in Afghanistan the efforts to reestablish the traditional pistachio industry and develop pistachios within new reforestation projects and on small farms will be presented. In Pakistan, the efforts to develop new and enhance perennial tree crops through introductions, establishing better nurseries, and teaching basic postharvest practices will be discussed.

2:15–2:30 PM

Training of Growers and Extension Agents in the Dominican Republic
Juan Diaz-Perez*
University of Georgia, Tifton, GA
Dharmalingam Pitchay
Tennessee State University, Nashville, TN
Roland Ebel
Autonomous University of the State of Mexico, Toluca, Mexico

The Dominican Republic is situated on the Hispaniola Island in the Caribbean region. Its climate shows considerable variation over short distances and is the most diverse of the Caribbean. Annual average temperature is 25 °C, ranging from 18 °C (at higher elevations) to 28 °C (at sea level). Average annual rainfall is 1500 mm. Although sugar, coffee, cocoa, and tobacco are the principal cash crops of the country, the Dominican Republic shows an increasing production of citrus and tropical fruit (banana, pineapple, guava, tamarind, passion fruit, soursop, and coconut), spices, nuts, and vegetables (tomatoes, carrots, lettuce, cabbage, coriander, scallions, onions, and garlic). Regarding the latter, diverse peppers are also gaining increasing importance on the country’s export market. Usually, they are grown in tunnels and greenhouses, where producers are challenged by high temperatures that result in reduced fruit yield and quality.

In this presentation, the experience of training pepper growers and their extension personnel in the communities of San José de Ocoa, La Horma del Rifle, Las Auyamas, and Constanza will be shared. The objective was to train them on how to manage heat stress of bell pepper and other vegetable crops grown inside high tunnels and greenhouses. It was observed that bell pepper plants inside high tunnels showed symptoms of heat stress, including reduced plant and fruit size, small fruit number, and a mild leaf chlorosis. Growers were recommended to utilize shading nets (30% to 40% shade) placed on top of the high tunnel or greenhouse to reduce the incidence of solar radiation. Also, under warm conditions, they were advised to use white or silver plastic mulch (rather than black mulch) in order to reduce soil over-heating. To reduce air temperature inside high tunnels and greenhouses through the use of side vents and zenithal openings was suggested as well.
Academic scientists are trained to run individual programs, yet collaborative projects can leverage program specialties and funding strategies to further research objectives. Effective networking can lead to global collaborations that accelerate progress towards solving critical agricultural issues like pest and disease management and plant breeding. Many of the skills necessary for effective networking are rooted in personal relationships and building trust within a community. In the Rosaceae community, a U.S.-led effort that began as a group of scientists seeking to implement current technology to make breeding programs more efficient succeeded in securing funding of the RosBREED project by the USDA-NIFA Specialty Crop Research Initiative. In the project’s first five years, a global network of scientists developed tools and infrastructure to enhance resource allocations in Rosaceae breeding programs. This collaboration has grown considerably, with a second project, RosBREED: Combining Disease Resistance and Horticultural Quality, focused on using those tools and infrastructure to address global issues in disease resistance and horticultural quality in rosaceous crops.

8:20–8:40 AM
International Issues and Networking from F2F Program of USAID–Vega Organic Agriculture Project in Bangladesh
Dilip Nandwani*
Tennessee State University, Nashville, TN

8:40–9:00 AM
Launching Horticultural Projects Abroad: Networking and Other Matters
Michael Schnelle*
Oklahoma State University, Stillwater, OK

Workshop—Landscaping with Ecological Function
Sponsor: Ornamentals/Landscape and Turf Working Group
Moderator: Dayton Wilde
University of Georgia, Athens, GA

Objectives: The objective of this workshop is to bring together perspectives from different disciplines on ecologically functional landscaping.

Description: The USGS has projected that current development patterns will lead to a completely connected urban area from Atlanta to Raleigh. While this urban expansion will provide new opportunities for the nursery industry in the Southeast, it is expected to have a significant impact on the region’s ecosystems. There is increasing evidence showing that the inclusion of native plants in landscaping can reduce the impact of urban development on biodiversity. Ornamental plants that provide ecological services can be an important nursery product with both economic and environmental value. A multidisciplinary effort is needed to address the challenges of scaling-up landscaping with ecological function. This workshop brings together perspectives from ecology, landscape design, economics, and extension outreach.

8:00–8:30 AM
Real World Challenges of Using Native Plants—A Landscape Architect’s View
Steve Sanchez*
HGOR, Atlanta, GA

8:30–8:50 AM
Influence of Plant Parameters on Occurrence of Pollinator, Butterfly, and Beneficial Insect Visitations
Bethany Harris*
University of Georgia, Griffin, GA

8:50–9:10 AM
Consumer Preference and Willingness to Pay for Native and Non-invasive Plants
Chengyan Yue*
University of Minnesota, St. Paul, MN

9:10–9:30 AM
“Florida-Friendly Landscaping”: Smart Landscaping Today and Beyond
Esen Momol*
University of Florida, Gainesville, FL

Workshop—The Challenges of Rose Rosette Disease (RRD): An Update of the Combating RRD SCRI Project
Sponsor: Ornamental Plant Breeding Working Group
Moderator: David Byrne
Texas A&M University, College Station, TX

Objectives: The objective of this workshop is to provide an update on rose rosette disease research and current control recommendations.

Description: In the past few decades, Rose Rosette Disease (RRD) has spread from its source in the Rockies, through the Mid-West to the East coast. It now threatens to decimate the U.S. rose industry. Garden roses which form the cornerstone of the multi-billion dollar landscape industry, annually generate wholesale U.S. domestic bare root and container production valued at ~$400 million. RRD is caused by a novel plant virus, the Rose rosette virus (RRV), which is transmitted by...
wind-blown eriophyid mites (*Phyllocoptes fructiphilus*). Unlike other rose diseases it can kill a rose within two to three years of infection. Although this disease has been known for many decades, the causal virus was only identified in 2011. Current work to improve our ability to manage this disease starts with improving the diagnostics available to identify the presence of the pathogen by improving their sensitivity, specificity and their ease of use. The ultimate goal is to have a field diagnostic adaptable for use by the producer or consumer of the roses. Field and greenhouse work is assessing the life cycles and movement of the virus and mite and the control efficacy of various miticides, antiviral compounds, pruning strategies and planting designs on the control of RRD. Complementing this field and greenhouse work is the Rose Rosette Monitoring Network with utilizes 100s of volunteers from throughout the nation to track the disease and identify roses that have RRD and those that do not. These volunteers all will be trained and in turn train others about RRD detection and management. The long range aspect of this project is the identification of roses resistant to RRD and the development of the breeding lines and tools to most efficiently introgress the resistance into the commercial rose germplasm.

8:00–8:15 AM

**What Is Rose Rosette Disease?**

Brent Pemberton*

Texas A&M Agr. Res. & Ext. Ctr., Overton, TX

Kevin Ong

Texas A&M AgriLife Extension, College Station, TX

Mark Windham

University of Tennessee, Knoxville, TN

Jennifer Olson

Oklahoma State University, Stillwater, OK

David Byrne

Texas A&M University, College Station, TX

Rose Rosette Disease (RRD) is endemic to North America. In the past few decades, it has spread from its source in the western part of the continent, through the Mid-West to the East coast. The disease initially spread in the widespread naturalized *Rosa multiflora*. More recently, the disease has spread onto garden roses and now threatens to decimate the U.S. rose industry. Garden roses are a cornerstone of the multi-billion dollar nursery and landscape industry and annually generate ~$400 million wholesale value of domestic bare root and container production in the United States. RRD is caused by a novel plant virus of the genus *Emaravirus*, the Rose rosette virus (RRV), which is transmitted by wind-blown eriophyid mites (*Phyllocoptes fructiphilus*). Unlike other rose diseases it can kill a rose within two to three years of infection. Although this disease has been known for many decades, the causal virus was only identified in 2011. Symptoms of the disease can vary with rose cultivar, but commonly include proliferation of lateral shoots causing a witches broom symptom, unusual thorniness and reddening of the shoots, crinkling and rugosity in the leaves, and distorted flowers which lead to stunting, defoliation and eventual death of the plant. Besides being spread naturally via the mite vector, graft transmission is also possible. Mechanical transmission is considered unlikely, but may be possible under certain conditions. This disease epidemic has led to a research–industry collaboration that is working toward better diagnostics, optimal management strategies, widespread educational efforts, and the development of resistant rose cultivars.

8:15–8:30 AM

**Development of Serological and Molecular Diagnostic Tools for Rose Rosette Virus**

Binoy Babu*

University of Florida, Quincy, FL

Mathews Paret

University of Florida, Quincy, FL

Gary Knox

North Florida REC, Quincy, FL

Francisco Corona

Oklahoma State University, Stillwater, OK

Ramon Jordan

U.S. National Arboretum, USDA-ARS, Beltsville, MD

Rose rosette disease, caused by *Rose rosette virus* (genus *Emaravirus*) is a major threat to the rose industry in the United States. The only strategy currently available for disease management is early identification and eradication of the infected plants, thereby limiting its potential spread. This requires highly sensitive serological or molecular based diagnostic tools. With the aim of developing a serological diagnostic tool, rabbit polyclonal and several mouse monoclonal antibodies have been developed, specific to the nucleocapsid protein of RRV; and has been standardized for its application in several ELISA formats including double- and triple-antibody sandwich ELISA, as well as for membrane based assays. For molecular assays, reliable and sensitive diagnostic tools including real-time RT-PCR, Loop mediated isothermal amplification (LAMP), Helicase-dependent amplification utilizing self-quenched primers (HDA-SqP) and isothermal reverse transcription-recombinase polymerase amplification (RT-exoRPA) assay has been developed and validated. The sensitivity, specificity, speed, and potential of the serological and molecular tools developed for lab and field based detection of *Rose rosette virus* will be discussed.

8:30–8:45 AM

**Management of Rose Rosette Disease**

Mark Windham*

University of Tennessee, Knoxville, TN

Alan Windham

University of Tennessee, Nashville, TN

Frank Hale

University of Tennessee, Nashville, TN

Rose rosette disease (RRD) has been responsible for the destruction of thousands of roses in commercial and private landscapes throughout the Mid-South. The only management strategy has been to destroy symptomatic plants. Many of the
plants were not destroyed until large rosettes developed in the infected bushes. For four years we looked at pruning at first symptom detection of RRD, using a green barrier to impede movement of the vectors, preventativemiticide sprays and rogueing at symptom detection. Pruning out symptomatic foliage was ineffective for reducing RRD symptoms from emerging on other canes. Green barriers (1.8–2.1 m plants of Miscanthus sinensis) reduced incidence of RRD in test plots by more than 50%. Plants sprayed on 14-day spray intervals with Akari, Forbid, Kontos, or Talstar did not develop symptoms of RRD whereas all plants sprayed with water (control) were symptomatic for RRD by the end of year three. Monitoring roses daily for RRD symptoms and rogueing of plants at first detection of symptoms prevented plants less than 1 m away from becoming symptomatic for RRD.

8:45–9:00 AM

Monitoring: Volunteers and Their Role in Data Collection and Education

Kevin Ong*
Texas A&M AgriLife Extension, College Station, TX
Ashley Brake
Texas A&M AgriLife Extension, College Station, TX
Jennifer Olson
Oklahoma State University, Stillwater, OK

Rose rosette disease was described on the North American continent in the early 1940s. The causal agent, Rose Rosette Virus, was described in 2011. Current information notes that all roses are susceptible to this disease yet there are indications that some appear to be more tolerant than others. In the past few years, this disease has gained widespread notoriety as symptoms appear to be more prevalent. Thus there is a growing concern of increased incidence by all those who like roses. A lack of understanding of the pathogen, vector and the disease associated with RRD resistance to accelerate its introgression into a range of rose germplasm. Experiments in Tennessee and Delaware are in place to verify which cultivars are resistant. Although work is being done with the resistant species, the introgression process of transferring the resistance from a cultivated rose to develop new resistant rose types would be quicker than starting with resistance from a species rose. In both situations, breeding tools such as marker-RRD resistance associations are being explored. The protocol to generate molecular markers via genotyping by sequencing has been developed for roses and a consensus map with more than 1000 markers has been constructed. Crosses have been made among various RRD resistant rose species and putatively resistant commercial roses on both the diploid and tetraploid level. These populations will allow an accurate assessment of the inheritance of and the identification of markers associated with RRD resistance to accelerate its introgression into a range of rose germplasm.

(CEU Approved)

Workshop—Developing, Producing, and Expanding the Footprint of Bioenergy Crops and Technologies for Commercialization

Sponsor: BioEnergy Working Group
Moderator/Coordinator: Vanessa Gordon
USDA-ARS SEA Sugarcane Field Station, Canal Point, FL

Objectives: The objective of this workshop is to explore progress and opportunities in developing, producing, and commercializing new crops and technologies for emerging bioenergy sectors.

Description: Success of emerging bioenergy industries hinge on the simultaneous development and management of an entire supply chain ranging from crops to bioprocessing, on a sub-
An asterisk (*) in front of a name indicates the presenting author.
Workshop—Advancing Technology Adoption and Achieving Extension Impact: A Working Group Success Story

Sponsor: Nursery Crops Working Group

Moderator: Chris Marble
University of Florida/IFAS Mid-Florida REC, Apopka, FL

Coordinators: Amy Fulcher1, Anthony LeBude2, and Sarah White3

1University of Tennessee, Knoxville, TN; 2N.C. State University, Mills River, NC; 3Clemson University, Clemson, SC

Objectives: Participants will use the Southern Nursery IPM Working Group as a case study on working group synergy. Participants will learn how to start a working group, how an initial needs inventory can fuel future collaborations, how these collaborations enhance effective extension programming, and metrics for documenting working group productivity. Participants will learn how to evaluate electronic books provided as extension resources and hands-on workshops in order to successfully establish extension impact.

Description: Extension and research professionals in the Southeast United States formed the Southern Nursery IPM (SNIPM) Working Group in 2009 in order to foster collaboration, thereby enhancing programming, increasing synergistic opportunities, expanding delivery of specialized expertise to growers, and leveraging resources. The working group is a multi-disciplinary coalition composed of extension and research faculty in entomology, horticulture, plant pathology, and weed science. Topics covered will include: 1) how our productivity as a working group benefitted our stakeholders, our funding agencies, and our members; 2) how an initial needs assessment driven by stakeholders and strategic project selection was a catalyst for synergy, stimulating popular press, Extension, and refereed publications, novel programming and use of technology, and additional funding; 3) effectively evaluating stakeholders’ perceived value and adoption of e-books and technology presented during hands-on workshops; 4) assessing our overall impact and effectiveness as a working group and as individual faculty; and 5) working group pitfalls to avoid.

10:15–10:35 AM

Working Group Synergy Part I: Developing a Successful, Sustainable Working Group

Amy Fulcher*
University of Tennessee, Knoxville, TN

Anthony LeBude
North Carolina State University, Mills River, NC

Sarah White
Clemson University, Clemson, SC

Matthew Chappell
University of Georgia, Athens, GA

Asterisk (*) in front of a name indicates the presenting author.
work Group Bright Idea Award. Building a productive and lasting working group requires attracting a group of research and extension faculty with complementary expertise, listening to stakeholders, and translating stakeholder needs into grant priorities to help solve problems. This presentation will cover the inception of the working group, establishing need and working group focus, determining membership, explain the critical role of funding and using initial projects to build a foundation for future projects.

10:35–10:55 AM

**Working Group Synergy Part II: Creating Extension Impact and Maximizing Faculty Benefits**

Amy Fulcher*
University of Tennessee, Knoxville, TN
Sarah White
Clemson University, Clemson, SC
Anthony LeBude
North Carolina State University, Mills River, NC
Matthew Chappell
University of Georgia, Athens, GA
S. Kris Braman
University of Georgia, Griffin
J.H. (J.C.) Chong
Clemson University, Florence
Jeffrey Derr
Virginia Polytechnic Institute & State University, Virginia Beach, VA
Winston Dunwell
University of Kentucky REC, Princeton, KY
Frank Hale
University of Tennessee
William Klingeman
Univ of Tennessee, Knoxville, TN
Gary Knox
North Florida Res. & Ed. Ctr., Quincy, FL
Joseph Neal
North Carolina State Univ, Raleigh, NC
Nicole Ward Gauthier
University of Kentucky, Lexington
Alan Windham
University of Tennessee, Nashville, TN

Extension and research professionals in Southeastern states formed the Southern Nursery IPM (SNIPM) working group to foster collaboration and leverage resources, thereby enhancing Extension programming, increasing opportunity, and expanding delivery of specialized expertise to nursery crop growers across a region. A striking benefit of working group membership was observed over time—a synergy. Greater awareness of individual expertise among SNIPM working group members focused on different aspects of the nursery system stimulated multi-state Extension publications, popular press articles, and spin-off research projects when separate foci were combined together and directed toward complex challenges. How to capture that synergy and maximize it is the emphasis of this presentation. Topics covered will include: 1) how our stakeholders, our funding agencies, and we as co-PIs, have benefited from our membership in a working group; 2) how funding to develop a Pest Management Strategic Plan and Crop Profile has had a multiplier effect, stimulating Extension and refereed publications, projects, and additional funding; and 3) the ratio of deliverables to funding and how group synergy increased our ability to generate these deliverables.

10:55–11:15 AM

**iBooks—Effectively Evaluating Impact of eBooks for Extension Audiences**

Matthew Chappell*
University of Georgia, Athens, GA
Sarah White
Clemson University, Clemson, SC
Amy Fulcher
University of Tennessee, Knoxville, TN
Anthony LeBude
N.C. State University, Mills River, NC
Gary Knox
North Florida Res. & Ed. Ctr., Quincy, FL
William Klingeman
Univ of Tennessee, Knoxville, TN
Frank Hale
University of Tennessee
Alan Windham
University of Tennessee, Nashville, TN
J.H. (J.C.) Chong
Clemson University, Florence
S. Kris Braman
University of Georgia, Griffin, GA
Jeffrey Derr
Virginia Polytechnic Institute & State University, Virginia Beach, VA
Joseph Neal
North Carolina State University, Raleigh, NC
Steve Frank
North Carolina State University, Raleigh, NC
Winston Dunwell
University of Kentucky Res. & Ed. Center, Princeton, KY
Mathews Paret
University of Florida, Quincy, FL
Nicole Ward Gauthier
University of Kentucky, Lexington
Chris Marble
University of Florida, Apopka, FL
Francesca Peduto Hand
Ohio State University, Columbus OH

Printed materials are the traditional method of delivering topic-focused information to a broad audience, but as use of
mobile devices has increased—use of these devices to reference information is commonplace. eBooks can be an effective resource in the Extension toolbox, facilitating delivery of text, graphical, and even video content. The Southern Nursery IPM (SNIPM) working group has created and published Extension materials as eBooks because the publishing interface is easy to use and facilitates integration of interactive content, while maintaining the capacity to create print versions of the content. Stakeholders are also familiar with the download interface, be it via eBooks or downloadable pdf files. Co-authors wrote three books; “IPM for Select Deciduous Trees in Southeastern US Nursery Production” and “IPM for Shrubs in Southeastern US Nursery Production: Volumes I and II.” To broaden availability of these resources beyond those with Apple devices, we released print and pdf versions of the books. For these Extension resources, pdf downloads have exceeded eBooks downloads [approximately 6:1 (trees and shrubs vol. I)]. Also interesting is the international impact of these resources, as downloads have occurred in 66 countries (tree book), in addition to downloads in the United States. The economic value of these resources is more difficult to calculate, but when nursery growers and Extension personnel were surveyed, 63% said book content was very useful, with the remaining 37% indicating the content was useful. In addition, average value of information with regard to either increased savings or earnings was $3,313. We are working to further refine survey techniques so we gain added feedback on these resources.

11:15–11:35 AM

Experiential Nursery IPM Workshop Series to Enhance Grower Practice Adoption

Anthony LeBude*
North Carolina State University, Mills River, NC
S. Kris Braman
University of Georgia, Griffin, GA
Nicole Ward Gauthier
University of Kentucky, Lexington, KY
Joseph Neal
North Carolina State University, Raleigh, NC
Matthew Chappell
University of Georgia, Athens, GA
Amy Fulcher
University of Tennessee, Knoxville, TN
William Klingeman
University of Tennessee, Knoxville, TN
Jeffrey Derr
Virginia Polytechnic Institute & State University, Virginia Beach, VA
Gary Knox
North Florida Res. & Ed. Ctr., Quincy, FL
Craig Adkins
N.C. State University, Lenoir
J.H. (J.C.) Chong
Clemson University, Florence

Winston Dunwell
Univ of KY Res & Ed Center, Princeton, KY
Frank Hale
University of Tennessee
Sarah White
Clemson University, Clemson, SC
Jean Williams-Woodward
University of Georgia, Athens, GA
Alan Windham
University of Tennessee, Nashville, TN

Three, two-day, hands-on, experiential workshops were presented in Quincy, FL, Decherd, TN, and Raleigh, NC, to both Cooperative Extension agents and growers in June 2014. Space was limited to 35 participants due to the hands-on nature of teaching. Four disciplines, Entomology, Plant Pathology, Weed Science, and Horticulture/Technology each had four hours to provide attendees content, which consisted of illustrated lectures, plant and pest samples used for identification, calculation of soil physical properties, irrigation assessments, and scouting walks through both nursery and landscape. Growers at each workshop were given a demographics survey when they arrived on day 1 (n ≤ 51). After each four-hour discipline session, attendees completed a survey to determine their gains in knowledge for the discipline and gains in building skills for completing some of the tasks presented. Additionally, attendees were asked which of the skills presented they might adopt into practice over the summer. An end of season survey (5 months later; n ≤ 15) was sent to growers to determine which practices were adopted, how they affected their production practices, and whether or not they will continue the practices in the future. The growers changed their behavior and adopted management practices as a result of attending. Initially, this group of growers was similar to another group called G2, defined as medium level practitioners of IPM by LeBude et al. (2012). For some practices, a higher percentage of growers in the present group adopted these tasks compared to those in G2. For other practices, adoption was similar or slightly less than growers in G2. Without exception, the growers attending the workshops are better practitioners of IPM, and prove that those within the larger context of G2 in the southeast are equally capable of learning new practices and adopting them in higher percentages given adequate educational opportunities and resources. A follow-up study will be conducted in 2016 to determine if these practices were continued by the population. Additionally, efforts need to be made, both empirically and in practice, to determine how effective these practices are in nursery production systems in terms of economic impact and improving plant health and will be reported. Complete training and education kits with instructions, supply lists, and either recorded or provided presentations are needed with embedded evaluation tools that can send efficacy information through smartphones of participants.

An asterisk (*) in front of a name indicates the presenting author.
Workshop–Pollinators: Understanding Consumer Attitudes and Identifying Insect-beneficial Plants
Sponsor: Marketing and Economics Working Group
Moderator/Coordinator: Chengyan Yue
University of Minnesota, St. Paul, MN

Objectives: This workshop explores the issues related to pollinators in consumer horticulture and production agriculture. Presentations will feature an understanding of the issues surrounding pollinators, consumer perceptions, preferences and attitudes toward pollinators, as well as identification of plants attractive to pollinators.

Description: Pollination is a critical ecosystem service provided by beneficial insects. More than 70% of plant species rely on pollinators to transport pollen. Insect-pollinated agricultural and horticultural crops contribute up to one third of food globally. However, in the past few decades, honey bees and other pollinators have disappeared at alarming rates. Habitat loss or fragmentation and use of certain insecticides have been identified as primary threats to pollination services. It is imperative for key stakeholders such as plant breeders, horticultural industry professionals, policy makers, and consumers to identify the real causes and take actions to help combat pollinator loss. Consumers and plant breeders can be influential players to facilitate the restoration of pollinator habitats. An overview of the current situation of the pollinator issues will be provided. Consumer perceptions, preferences and attitudes toward insecticide attributes, pollinator-friendly plants and insect management strategies, and how information affects their perception for pollinators will be presented. The investigation of companion planting in attracting pollinators and predatory insects to vegetable crops will be discussed.

10:15–10:30 AM
Honey Bee, Agroecosystem, and Effects of Neonicotinoids
Mengmeng Gu*
Texas A&M AgriLife Extension, College Station, TX

10:30–10:45 AM
Consumer Preferences and Willingness to Pay for Insecticides’ Attributes
Chengyan Yue*
University of Minnesota, St. Paul, MN

10:45–11:00 AM
How Various Information and Information Sources Impact Perception and Preference for Pollinators
Ben Campbell*
University of Georgia, Athens, GA

11:00–11:15 AM
Understanding How Consumers View Pollinator-friendly Plants: Connecting Gaze Data to Purchasing Behavior
Hayk Khachatryan
University of Florida/IFAS, Apopka, FL
Alicia Rihn*
University of Florida, Apopka, FL

11:15–11:30 AM
Consumer Attitudes about Neonicotinoids, Perceptions of Insect Management Strategies, and the Relative Value of Those Diverse Insect Management Strategies and Other Eco-practices
Bridget Behe*
Michigan State University, East Lansing, MI

11:30–11:45 AM
The Effect of Floral Companion Plants for Beneficial Insect Abundance and Yield of Selected Vegetable Crops
Janet Cole*
Oklahoma State University, Stillwater, OK
Janet Steets
Oklahoma State University, Stillwater, OK
Eric Rebek
Oklahoma State University, Stillwater, OK
Brian Kahn
Oklahoma State University, Stillwater, OK

Workshop–Sustainable Horticultural Practices in Asian Countries
Sponsor: Working Group of Asian Horticulture
Moderator/Coordinator: Shengrui Yao
New Mexico State University Sustainable Agriculture Sciences Center, Alcalde, NM
Coordinator: Kedong Da
Institute for Advanced Learning and Research, Danville, VA

Objectives: To introduce sustainable horticultural practices that are popularly used in Asian countries to ASHS members.

Description: Asian countries have a long history of horticultural production, have explored and accumulated many unique and sustainable horticultural practices. With limited land and high population, most of those cultural practices are labor intensive like fruit bagging which greatly reduces pesticide application and improve fruit quality. The low-tech Chinese greenhouse and high tunnels are also very popular in China for vegetables, fruit and cut-flower production. Aquaponics has long been practiced in China and Thailand. The four topics covered in this workshop would introduce ASHS members to popular sustainable horticultural practices in Asian countries. Some of them are also...
Aquaponics: The Next Generation Farming System

Hye-Ji Kim*
Purdue University, West Lafayette, IN

Considerable pressure has been placed on agricultural resources due to the major risks associated with long-term food security such as climate change, extreme weather events, rapid population increase, and the shortages of fresh water and cropland. The next generation farmers are facing unprecedented challenges in sustaining crop production to meet global demands. Aquaponics is a smart farming that integrates aquaculture with hydroponics to grow various crops using fish wastewater in a recirculating system. Aquaponics recycles more than 98% of water from aquaculture effluents for crop production, dramatically reducing discharge of its wastewaters into the environment, with greater potential for profitability by simultaneously producing two cash crops, fish and plant crops. Fish feed determines mineral nutrients available for plant production as it provides most of the nutrients required for plant growth. Although many different types of crops have been tested and grown in aquaponics, the crop choice largely depends on the experience and personal preference of the farmer. There is a lack of scientific information on the type of crops best suited to aquaponics systems. Therefore, a holistic approach to effectively manage aquaponics systems is critical to produce higher crop yields and quality while more effectively conserving water and nutrient resources from the wastewater. In this presentation, the opportunities and challenges of aquaponics systems will be discussed, and the strategies for the effective management will be highlighted for better performance of aquaponics systems.

The Low-tech Yet High Performance, Off-grid Chinese Greenhouse

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

The protected vegetable production in China had a share of less than 20% of the total 20 million hectare for vegetables, thus producing 40% of the total vegetables or 60% of the total value. While the traditional greenhouse has seen its steady growth, almost 10% each year, the widely employed season extension facilities have been low-tech plasticulture systems such as solar greenhouse, high/low tunnels, and plastic mulch. The solar plastic greenhouse, or Chinese Solar Greenhouse, has played a key role in winter production of vegetables. Developed in 1989 in Shandong, the largest vegetable production province, this passive solar greenhouse is able to produce warm season vegetables, small fruits, and tree fruits in winter without supplemental heating. The structure of greenhouse consists of three thick, solid walls (north, west and east side), and a “roof” connected to the north wall. The rest of structure is covered with plastic films. At night, an insulation blanket, which rests on the roof during daytime, will be released to cover the plastic film for added protection from low temperatures. The Chinese Solar Greenhouse was initially made with soil (walls), bamboo sticks (supporting columns), galvanized wires (network to support plastic films and blankets), and straws (blankets). Later, improved designs feature wider span (from 7 to 10m), increased height (from 2 to 4m), reduced number of supporting columns (only one row at the back to support the roof), steel structure, lighter thermal blankets, automated blanket rolling-up/down system, and improved ventilations. The key practices developed include disease resistant cultivars that are tolerant to low temperature and light, vegetable grafting for soil-borne disease resistance and abiotic stress tolerance, trellising and pruning, and CO₂ enrichment. The crop choices and disadvantages of Chinese Solar Greenhouse, and its possible adaptation among small farmers in the United States will be discussed.

Fruit Bagging for Organic and Quality Fruit Production

Kedong Da*
Institute for Advanced Learning and Research, Danville, VA

Fruit bagging is a cultivation technique that provides physical protection of fruit from early stages of fruit development to harvest. Fruit bagging can potentially increase farmers’ incomes through improved fruit quality. The technique allows for the production of organic fruits by utilizing environmentally friendly measures, thus optimizing human health through reduced exposure to pesticide residues. Fruit bagging originated in the early 20th century in Japan. The technique was first being applied to the cultivation of pears and grapes, and then extended to varieties of apple. Fruit bagging was quickly applied to fruit production in Japan, Korea and China in the early 1970s because of the significant improvement of quality in bagged fruits, and now remains a standard practice for quality fruit production in these countries. Fruit bagging continues to develop as new materials and technology become available. This presentation is designed to provide information for the promotion of the technology in North America; and will discuss fruit bagging techniques including: 1) effect of fruit bagging; 2) selection of different bags; 3) suitable bagging time; 4) bagging methods; and 5) bag removal methodology and timing.

Using High Tunnel As a Sustainable Tool for Specialty Crop Production

Mengmeng Gu*
Texas A&M AgriLife Extension, College Station, TX

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Mengmeng Gu*
Texas A&M AgriLife Extension, College Station, TX

HortScience 51(9) Supplement—2016 ASHS Annual Conference
High tunnel has been used extensively as a sustainable tool for specialty crop (vegetables, fruits and cut flowers) production in China. The three main types of protected structures are low tunnels, high tunnels and solar greenhouses (mainly in north China with very low winter extreme temperatures) in China. An accurate total area of low tunnels and high tunnels is hard to be decided since many are constructed with very low cost and renewable materials (like bamboo and wood) and could be erected or dismantled based on production needs from year to year. The area under solar greenhouse production was over 700,000 ha in 2010. For vegetable production, there were over 4 million ha under protection (including high tunnel) in 2010, which was over 95% of all protected horticulture production in China and over 80% of all protected vegetable production in the world. The main advantages of using high tunnels in specialty crop production include premium prices for out-of-season and out-of-natural-production-area produces, low agrochemical inputs and high quality, which could all be translated to sustainable farmers’ income and consumer satisfaction.

Workshop—Coordinating Researcher and Stakeholder Advocacy for Greater Impact

Sponsor: National Issues Committee
Coordinator: Thomas Björkman
Cornell University, Geneva, NY,

Objectives: Horticulture has had remarkable success with advocacy for research and extension programs over the past 5 to 10 years. An important contributor to that success was consistent messaging between a well-organized industry-stakeholder group and the research community who would do the work. This interactive workshop will have a panel of experts to review what was effective about the advocacy to date so that we can coordinate effectively within our state and nationally.

Description: ASHS members will be able to apply lessons from this workshop in working with state and regional grower organizations to carry their advocacy to university, state, or national policymakers, in order to make sure horticultural research and extension get the attention they need and deserve. The panel will help analyze ideas or efforts from the audience to help devise more effective strategies. What have been successful ways to agree upon a unified message when there are many disparate narrow priorities among the allied groups? What are ways to make long-term investments high-priority with growers who tend to focus on immediate issues like labor in their legislative advocacy? How is advocacy different nationally versus within individual states? The panelists have expertise in coordinating with other groups, each from their own perspective. They will provide overall insights in an introductory statement, and then help analyze specific situations that audience members bring to help make current efforts more effective.

10:15–10:30 AM
Stakeholder Advocacy for Research Funding
Charles Hall*
Georgia Fruit and Vegetable Growers Association, LaGrange, GA

10:30–10:45 AM
How Researchers Can Coordinate Their Message with Stakeholders
John Lea-Cox*
University of Maryland, College Park, MD

10:45–11:00 AM
Setting Legislative Goals That Satisfy Both Researchers and Stakeholders
James McFerson*
Washington State University, TFREC, Wenatchee, WA

11:00–11:15 AM
How Legislative Staff Perceive Coordinated Messaging
Jonathan Moore*
ASHS, Alexandria, VA

11:15–12:00 PM
Achieving Better Coordination in Your Advocacy (Audience Scenarios)
Thomas Björkman*
Cornell University, Geneva, NY

Workshop—Novel Challenges and Opportunities in Tropical Ornamental Horticulture: Orchids As a Model Crop

Sponsor: Tropical Horticultural Crops Working Group
Moderator/Coordinator: Hideka Kobayashi
Kentucky State University, College of Agriculture, Food Science, and Sustainable Systems, Frankfort, KY

Objectives: 1) Provide a platform for scientists, educators, industry leaders, and growers to evaluate the challenges and opportunities of tropical horticulture using orchids as a model. 2) Provide interaction and networking opportunities for scientists in different disciplines, including biotechnology, ecology, entomology, plant pathology, and horticulture science to identify and recommend key research criterion. 3) Evaluate the needs and assess the hurdles for future opportunities of tropical floriculture and ornamentals.

Description: Production of ornamentals and floriculture in tropics has faced considerable challenges lately. Some of the challenges include newly emerging pests and diseases, ever-rising fuel cost for production, sustainability and impacts on environment, and germplasm preservation due to rapidly decimating populations of genetic materials. Additionally, genetic engineering is now employed to enhance aesthetic quality of
ornamental crops. These challenges have concurrently created various opportunities for horticulture scientists to tackle. Among many tropical and subtropical ornamental crops, orchids have strong potential. Orchid sales have drastically increased over the last few decades. According to USDA, orchids are the number one floriculture crop in wholesale value, which has increased 206% from 1996 to 2006, while wholesale value for many other floriculture or ornamental crops such as poinsettia and African violets have stayed the same or even decreased. Orchids were once exclusive to aristocrats and wealthy people. Nowadays, consumers can purchase reasonably priced blooming *Cymbidium*, *Dendrobium*, and *Phalaenopsis* plants at local grocery and hardware stores. This recent popularity of orchids is a culmination of steady and persistent advances in ornamental horticulture research, starting with in vitro asymptotic seed germination, mass clonal propagation as well as investigation on crop physiology, cultural requirements, and pest and disease control. This colloquium will look at challenges and opportunities that tropical ornamental crops are currently facing, using orchids as a model crops with a wider application to other horticultural crops.

1:45–2:00 PM

**Commercial and Amateur Orchid Production in the United States**

Ronald McHatton*
American Orchid Society, Coral Gables, FL

Orchid sales have dramatically increased over the last few decades. Orchids are currently the number one floriculture crop in wholesale value, increasing from 206% from 1996 to 2006 according to USDA, while the wholesale value for many other floriculture or ornamental crops has stayed the same or even decreased during the same period. Presently, consumers can purchase reasonably priced blooming *Cymbidium*, *Dendrobium*, and *Phalaenopsis* plants at local grocery and hardware stores. Tropical orchids remained luxury items for over a century until George Morel, a French scientist, developed methods to mass produce *Cymbidium* orchids. A long history in cultivation and breeding efforts have resulted in many easy-to-grow orchids such as *Phalaenopsis amabilis* hybrids, *Dendrobium bigibbum* hybrids, and *Oncidium* hybrids for mass production. Nowadays, of various orchid species and hybrids are grown by both amateur and commercial growers. In this presentation, a history of orchid cultivation along with the current status of orchid production will be discussed.

2:00–2:20 PM

**Conservation of Native Orchid Species at Atlanta Botanical Gardens**

Matthew Richards*
Atlanta Botanical Gardens, Atlanta, GA

Jennifer Cruse-Sanders
Atlanta Botanical Gardens, Atlanta, GA

Ronald Determann
Atlanta Botanical Gardens, Atlanta, GA

2:20–2:35 PM

**Virus Eradication in a Selected Clone of *Dendrobium Jaq-Hawaii ‘Uniwai Pearl’***

Kenneth Leonhardt*
University of Hawaii at Manoa, Honolulu, HI

Amanda Ackerman
University of Hawaii at Manoa, Honolulu, HI

Sarah M. Marten
University of Hawaii at Manoa, Honolulu, HI

Bailee Morrison-Fogel
University of Hawaii at Manoa, Honolulu, HI

Viral infection poses one of the greatest threats to orchid health. *Cymbidium mosac virus* (CymMV) is the most prevalent virus on *Dendrobium* orchids worldwide. A variety of symptoms including distorted petals and necrotic streaks and spots on flowers and foliage, can reduce the marketability of both cut flowers and potted plants. *Dendrobium Jaq-Hawaii ‘Uniwai Pearl’*, also known as ‘UH 306’, is a widely grown, high-yielding, long spray, white, amphidiploid cultivar grown from seed. Populations of plants are uniform for most characteristics, but superior selections can be made. In a trial of 990 plants the average yield for a 12-month period was 26.5 sprays per plant, with one exceptional individual yielding 64 sprays. Unfortunately, this plant was infected with CymMV. The plant was cultured and tissues were treated in vitro with antiviral compounds Ribavirin at 9.8 μL per 125 mL flask or Dithiouaracil at 29 μL per 125 mL flask. Flasks were placed on a rotary shaker at 125 rpm, under 40 Watt Sylvania lights for 24 hours at 25 °C. One year later tissues from treated plants were assayed using Agdia ImmunoStrip® technology and several virus-free plants were identified.

2:35–2:50 PM

**Anthurium and Dendrobium Orchid Breeding in Hawai‘i**

Teresita Amore*
University of Hawaii, Honolulu, HI

Anthurium and dendrobium orchids are two of the leading tropical flower commodities in Hawaii. The University of Hawaii’s *Anthurium* and *Dendrobium* orchid breeding programs started in 1950, and is one of the few publicly funded flower breeding programs. The breeding program has generated to date 50 *Anthurium* and 32 *Dendrobium* varieties for commercial cut flower and potted plant production. This talk will present an overview of the breeding programs’ accomplishments over the past 66 years.

2:50–3:05 PM

**Light Quality Enhancement of Growth and Flowering of Orchids**

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

Various cultural practices are available to growers to help improve the growth and flowering of orchids. The manipulation of light quality is such a cultural practice. Altering light quality can be
done through photosensitive shade cloths and light-emitting diodes (LEDs). They help to enhance the culture of potted orchids and micropropagated orchids.

(CEU Approved)

Workshop—Innovative Applications of Computers in Horticulture

Sponsor: Computer Applications in Horticulture
Moderator/Coordinator: Guihong Bi
Mississippi State University, Mississippi State, MS

Coordinators: Arthur Villordon and Kent Kobayashi
1Louisiana State University Ag Center, Chase, LA; 2University of Hawaii at Manoa, Honolulu, HI

Objectives: To familiarize the audience with several of the latest innovative computer applications in horticulture for research, extension, and instruction.

Description: With ever-changing developments in computers, software, and high technology, one’s professional development calls for keeping abreast of the latest innovative applications. Three speakers will present their experiences with innovative applications of computer usage developed for research, extension, and teaching. The audience will learn about acquiring 3D images using an inexpensive 3D scanner and trends in 3D image analysis, novel applications of drones in horticulture, and comparison of online meeting platforms.

3:30–4:00 PM

Integrating UAVs into Field Applications for Horticultural Scientists and Producers

Kurt Nolte*
University of Arizona, Yuma, AZ

Rosa Bevington
University of Arizona, Yuma, AZ

The use of micro-UAVs (Unmanned Aerial Vehicles) for field researcher and commercial production has recently gained considerable attention as an alternative image capture and data acquisition platform. And, technological improvements in camera stabilization, miniaturized optical systems, enhanced payload capacity, complete autonomous navigation and improved the flying performance has resulted in using UAVs as a low cost alternative to the classical manned aerial systems. Practical use of UAV systems, imagery capture equipment and post-flight processing will be discussed in reference to producing a product that provides either research or commercial utility. This presentation will include a brief overview of using UAVs in 3D field modeling, plant stand assessment, plant growth dynamics, NDVI (Normalized Difference Vegetation Index) ratio calculations, field mapping, irrigation monitoring and aerial pollination. The great advantage of utilizing UAV systems is the ability to quickly deliver high temporal and spatial resolution information and to allow a rapid response in a number of field situations where immediate access to aerial imagery is either crucial or adds a layer of useful information to a problem.

Opportunities for Incorporating Desktop and Mobile Videoconferencing Solutions in Teaching and Extension Programs

Tim Rhodus*
Ohio State University, Columbus, OH

A form of technology employed by horticulturists that has seen significant advancements over the past 25 years is videoconferencing. Attempting to see, hear, and talk to one person or a group of people at a distance in the 1990s required access to very expensive proprietary equipment, software, network connections, and compatible systems at both ends. Today, one-to-one conversation between people (point-to-point) or among multiple parties (multipoint) is possible on laptop computers and even mobile devices using built-in hardware and free accounts from cloud vendors. In addition to voice and visual communications, today’s meeting software also allows users to share documents, display desktop applications, and switch presenters. This session will feature both large-scale and free conferencing systems. Features such as scheduling, recording, and options for mobile devices will be discussed. Implications for self-recording software tutorials, website demonstrations, and audio/video feedback to assignments or questions submitted by others will be used as examples for developing teaching and extension instructional materials using a videoconferencing system.

4:30–5:00 PM

Using a Low-cost Scanner for 3D Shape Acquisition: Applications in Horticultural Research

Arthur Villordon*
Louisiana State University Ag Center, Chase, LA

An important aspect in horticultural research is the shape in three dimensions that reflects adaptation to environmental conditions. 3D representations can convey information not obtainable from 2D images. Current commercial systems for capturing plant shape based on regular RGB cameras can measure some parameters like projected plant area but fail to exploit the full potential of 3D shape analysis. Advances in sensors and algorithms and more recently from the gaming industry and 3D printing have spurred the development of low-cost sensor systems. Laser scanning devices are currently available for coarse measurement like estimating biomass or canopy. However, relatively expensive laser scanners with higher resolutions are needed for observation of smaller objects like fruits and other storage organs. Thus, there is a need for low-cost 3D imaging techniques to address the trade-off between efficiency of image acquisition and the cost of the sensor system with sufficient accuracy. In this presentation, a low-cost 3D scanner will be used to demonstrate the generation of 3D models and acquisition of parameters like length, area, and volume of some plant organs like fruits, tubers, and storage roots. The advantages and disadvantages of this 3D scanner will be discussed. The prospects and limitations of using 3D scanners in horticulture research will be addressed.
Workshop–Student Career: Speed-dating on Career Options, 4th Edition

Sponsor: Industry Division
Moderator/Coordinator: Angela Davis
Davis, CA

Objectives: To provide students short and quick “live” autobiographies from several well-known Industry researchers, to hear their stories on education, research pathways, and career choices, and solicit ideas on their own career options and opportunities.

Description: When it comes to determining career pathways, students can be faced with vastly different opportunities. These career choices can include positions in industry, university, government or even private consulting. Given that industry often leads to exciting and rewarding careers, this workshop introduces students to industry scientists and technical people in a fun and quick-paced way. Scientists from several horticultural companies will give a brief description of their education, past experience, current roles and responsibilities, and provide humble advice for students looking at career options, with emphasis on how their education has supported their career path. In addition to a quick Q&A, students can take time afterward to mingle and discuss career ideas with the speakers.

3:45–4:00 PM
Speaker
Andrea Melnychenko*
CID Bio-Science, Inc., Camas, WA

4:00–4:15 PM
Speaker
Dean Kopsell*
The University of Tennessee, Knoxville, TN

4:15–4:30 PM
Speaker
Angela Davis*
Davis, CA

4:30–4:45 PM
Speaker
Holly Little*
Acadian SeaPlants, Sacramento, CA

Workshop–Invasive Plant Management and Restoration: New Research, Goals and Opportunities for the Ornamental Horticulture Industry

Sponsor: Invasive Plants Research Working Group
Moderator/Coordinator: Chris Marble
University of Florida, Apopka, FL

Objectives: 1) Provide a source of information about the ways in which invasive plant species impact native plant communities and our environment. 2) Present research on new management strategies and on ways in which invasive plant introductions can be reduced. 3) Discuss the role of the ornamental horticulture industry in invasive plant management including current challenges, opportunities, and future research needs.

Description: Ornamental horticulture has been recognized globally as one of the main sources of plant invasions. Studies have shown that approximately 80% of woody plant species that have been identified as invasive were introduced, at least in part, for ornamental purposes and once used as landscape plants. Many of our most common invasive plant species were once popular among gardeners and landscapers for their interesting foliage, fruit, or flower production, pest resistance, or other growth characteristics. However, some of these species escaped cultivation and began displacing native vegetation and wildlife, clogging waterways, impacting crop growth, and reducing property values. The nursery industry is facing a difficult dilemma; balancing the ongoing need to meet customer demand and introduce new plants while also avoiding the spread of potentially invasive plant species. The objective of this workshop is to present research on invasive plant management focusing on new methods of chemical management, screening protocols, and breeding sterile or non-invasive cultivars that will bring value to the nursery industry.

4:00–4:15 PM
Domestication, Breeding and Selection of Noninvasive Horticultural Crops: Feasibility versus Impracticality

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

Following the development of our noninvasive crop ideotype in 2006, a trait-based species design to develop crops as noninvasive a priori market release, we delineated additional components needed to bring such products to market. Education of consumers and professionals upwards through the horticultural distribution chain was identified as a critical component to create demand for noninvasive plants. Our auctions of invasive and noninvasive floriculture crops demonstrated consumer willingness to pay increases when plants are native and noninvasive. However, noninvasive plants have the same phenotype as invasive ones, which challenge breeders and producers to embrace the noninvasive ideotype without recapturing investments. The feasibility of risk assessment varies based on species’ trait constituents, adaptability, stability, and propagation modes. Additionally, the most rigorous procedures involve lengthy trialing over years and locations for proven trait stability, similar to the long-term developmental costs for winter hardy or GMO crops. To identify invasive potential, it would be feasible if spread and establishment occurs in the first decade or less of trialing in any or all target environments, i.e. Anthriscus sylvestris, Gaura lindheimeri, and Verbena bonariensis. Whereas it would be impractical for species requiring decades or centuries to establish, e.g., Leucanthemum vulgare, Lythrum salicaria or Phalaris arundinacea. For the
impractical species, alternative approaches exist although each would involve considerable cost investments.

4:15–4:30 PM

**Developing a Plant Risk Evaluation and Cultivar Decision System for Regional Markets**

John Ruter*  
University of Georgia, Athens, GA

4:30–4:45 PM

**Screening Potential Invasive Species to Select Superior Parents—**Miscanthus** As an Example**

Matthew Chappell*  
University of Georgia, Athens, GA

4:45–5:00 PM

**Integrated Management of Waterhyacinth (Eichhornia crassipes), the Floating Scourge of the South**

Lyn Gettys*  
University of Florida Fort Lauderdale REC, Davie, FL  
Jeremiah Foley  
USDA-ARS Invasive Plant Research Laboratory, Fort Lauderdale, FL  
Phillip Tipping  
USDA-ARS Invasive Plant Research Laboratory, Fort Lauderdale, FL  
Carey Minter  
USDA-ARS Invasive Plant Research Laboratory, Fort Lauderdale, FL

5:00–5:15 PM

**Control of Invasive Ruellia Simplex By Herbicide Treatments in Natural Areas and Breeding Sterile Cultivars**

Rosanna Freyre*  
University of Florida, Gainesville, FL  
Adrienne Smith  
University of Florida, Gainesville, FL  
Carrie Reinhardt-Adams  
University of Florida, Gainesville, FL  
Zhanao Deng  
University of Florida, Wimauma, FL  
Gary Knox  
North Florida REC, Quincy, FL  
Sandra Wilson  
University of Florida, Fort Pierce, FL

Ruellia simplex (Mexican petunia) is native to Mexico and Western South America. It has profuse flowering and low maintenance requirements, and is a popular landscape plant in the southern United States. However, this introduced plant has escaped cultivation and become invasive in natural areas in seven Southern States, Hawaii, Puerto Rico, and the U.S. Virgin Islands. For many years, ‘Purple Showers’ (origin unknown) with tall habit and purple flowers was the only sterile cultivar. One objective was to control invasive Ruellia simplex in natural areas. Twelve 3 m x 3 m plots were used in a floodplain forest wetland natural area in central Florida. Herbicide treatments included four levels of glyphosate application frequency (0, 1, 2, or 3 applications) and two application seasons (spring and fall). Results showed that glyphosate treatments reduced *R. simplex* by 60% to 70% when sprayed once, either in the spring or the fall. Additionally, the plant composition of the seedbank and the potential for recolonization of the native plant community were assessed. Results indicate that the recovery of native species may be a multi-year process with several revegetation efforts, and that additional chemical control incorporating a growth regulator herbicide that targets *Ruellia* rhizome growth may be necessary. Additionally, we are developing sterile *Ruellia* cultivars with different flower colors and growth habits. Breeding techniques utilize ploidy manipulations and interspecific hybridizations. Tetraploid *R. simplex* plants in three different flower colors have been obtained by treating diploid plants with oryzalin. Hybridizations are performed between tetraploids and diploids, as well as between different morphotypes and species of *Ruellia*. Seeds are sown every year and progenies are grown in a greenhouse at Gainesville, Florida. Plants are selected for female sterility and lack of fruit formation, and their ploidy levels are determined by flow cytometry. Selected breeding lines and commercial cultivars as controls are evaluated in replicated field trials located in northwestern, north central and southwestern Florida. Breeding lines are evaluated monthly from May to September for landscape performance, flowering and fruiting. Selected lines with demonstrated female and male fertility need to be approved by the UF/IFAS Invasive Plants Task Force and the UF/IFAS Cultivar Release Committee. So far, we have released *Ruellia* ‘Mayan Purple’, ‘Mayan White’, and ‘Mayan Pink’, and all are commercially available. The first two cultivars are patented while ‘Mayan Pink’ is pending. Release of a fourth cultivar is in process, and breeding efforts are ongoing.

5:15–5:30 PM

**Efficacy and Cost of Selected Herbicides for Control of Skunkvine (Paederia foetida)**

Chris Marble*  
University of Florida, Apopka, FL  
Yingfang Xiao  
University of Florida Mid-Florida REC, Apopka, FL  
Annette Chandler  
University of Florida/IFAS Mid-Florida REC, Apopka, FL

Skunkvine (*Paederia foetida*) is a fast-growing, woody vine that is native to eastern and southern Asia. In the late 19th century, skunkvine was introduced into Florida as a potential fiber crop and quickly escaped cultivation and began invading natural areas throughout the state. By 1993, skunkvine was labeled a Category 1 species by the Florida Exotic Pest Plant Council and declared legally noxious in 1999. It has been documented in at least 25 counties in Florida and is a common nuisance in landscapes, agricultural production, and natural areas. Despite its prevalence, little information on herbicide efficacy exists. Herbicide dose-response trials were initiated at the Mid-Florida
Workshop

Workshop—Novel Challenges and Opportunities in Tropical Ornamental Horticulture: Orchid Biotechnology

Sponsor: Floriculture Working Group
Moderator/Coordinator: Hideka Kobayashi
Kentucky State University, College of Agriculture, Food Science, and Sustainable Systems, Frankfort, KY

Objectives: 1) Provide a platform for scientists, educators, industry leaders, and growers to evaluate the challenges and opportunities of tropical horticulture using orchids as a model. 2) Provide interaction and networking opportunities for scientists in different disciplines, including biotechnology, ecology, entomology, plant pathology, and horticulture science to identify and recommend key research criteria. 3) Evaluate the needs and assess the hurdles for future opportunities of tropical floriculture and ornamentals.

Description: Production of ornamentals and floriculture in tropics has faced considerable challenges lately. Some of the challenges include newly emerging pests and diseases, ever-rising fuel cost for production, sustainability and impacts on environment, and germplasm preservation due to rapidly declining populations of genetic materials. Additionally, genetic engineering is now employed to enhance aesthetic quality of ornamental crops. These challenges have concurrently created various opportunities for horticulture scientists to tackle. Among many tropical and subtropical ornamental crops, orchids have strong potential. Orchid sales have drastically increased over the last few decades. According to USDA, orchids are the number one floriculture crop in wholesale value, which has increased 206% from 1996 to 2006, while wholesale value for many other floriculture or ornamental crops such as poinsettia and African violets has stayed the same or even decreased. Orchids were once exclusive to aristocrats and wealthy people. Nowadays, consumers can purchase reasonably priced blooming Cymbidium, Dendrobium, and Phalaenopsis plants at local grocery and hardware stores. This recent popularity of orchids is a culmination of steady and persistent advances in ornamental horticulture research, starting with in vitro asymbiotic seed germination, mass clonal propagation as well as investigation on crop physiology, cultural requirements, and pest and disease control. This colloquium will look at challenges and opportunities that tropical ornamental crops are currently facing, using orchids as a model crops with a wider application to other horticultural crops.

4:00–4:15 PM

Cryopreservation and the Use of Bioreactor Technology in Clonal Propagation of Orchids

Wagner Vendrame*
University of Florida, Homestead, FL

4:15–4:30 PM

Why Artificial/Synthetic Seed Technology in Orchids?

Amir Khoddamzadeh*
Florida International University, Miami, FL

4:30–4:45 PM

Anthocyanin Regulatory/Structural Gene Expression in Phalaenopsis in Relation to Creating Blue Orchids

Robert Griesbach*
Research Operations and Management Office of Technology Transfer (USDA-ARS), Beltsville, MD

4:45–5:00 PM

Ploidy Levels and Uses of Laelia anceps Complex in Breeding Cattleya-type Orchids

Hideka Kobayashi*
Kentucky State University, College of Agriculture, Food Science, and Sustainable Systems, Frankfort, KY

Abstract: The Laelia anceps complex currently comprises of three distinct genotypes distributed in southern Mexico and a portion of Guatemala. Traditionally, two subspecies of L. anceps were recognized (L. anceps ssp. anceps and L. anceps ssp. dawsonii) but now both are considered distinct at least for registration purposes. The third species L. mottae was recently described for the Guatemalan population while not recognized by the Royal Horticulture Society. L. anceps complex and its closely related Mexican Laelia species such L. albida, L. gouldiana and L. rubescens have been used in Cattleya breeding to some extent to impart cold hardiness. Results from this type of breeding are generally favorable despite very long inflorescences, smaller flowers and shorter flower lives. Further attempt to improve Cattleya type orchids with L. anceps complex or its

An asterisk (*) in front of a name indicates the presenting author.
hybrids are sometimes hampered by the existence of different ploidy levels among *L. anceps* complex. Additionally, orchid growers have been improving *L. anceps* complex by breeding with notable clones such as ‘Mendenhall’ and ‘SanBar Marble King’ so that improved strains can be further used for breeding without knowing ploidy or realizing the true identity of clones used. In this presentation, three species of *L. anceps* will be described using examples of prominent clones. Furthermore, results from flow cytometric analyses will be presented to identify polyploid clones of *L. anceps* complex.

5:00–5:15 PM
**In Vitro Polyploid Induction of Orchids Using Oryzalin**

Kenneth Leonhardt*
University of Hawaii at Manoa, Honolulu, HI

Tilden Miguel
University of Hawaii at Manoa, Honolulu

A protocol for in vitro polyploid induction using oryzalin was developed for *Dendrobium*, *Epidendrum*, *Odontioda*, and *Phalaenopsis* orchids (Orchidaceae). Protocorms and protocorm-like bodies (PLBs) in liquid nutrient media were subjected to oryzalin treatments of 14.4, 28.9, and 57.7 fLM (w/v) concentrations for 3 and 6 days. Higher concentrations and longer treatment durations lowered the survival rates of the explants, but increased the number of polyploids produced. Stomatal guard cell lengths as measured with digital image analysis software, helped to identify several polyploids from digital images of leaf imprints. The optimal treatments were: 14.4 fLM for 6 days in *Dendrobium* and *Odontioda*; 57.7 fLM for 6 days in *Epidendrum*; and, 14.4 fLM for 3 days in *Phalaenopsis*.

5:15 PM – 5:30 PM
**Future of Orchid Research**

Hideka Kobayashi*
Kentucky State University, College of Agriculture, Food Science, and Sustainable Systems, Frankfort, KY

Robert Griesbach
Research Operations and Management Office of Technology Transfer (USDA-ARS), Beltsville, MD

Wagner Vendrame
University of Florida, Homestead, FL

Amir Khoddamzadeh
Florida International University, Miami, FL

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Workshop—Horticulture Industry in India: Opportunities and Challenges

Wednesday, August 10, 2016
(CEU Approved)

Sponsor: Association of Horticulturists of Indian Origin Working Group

Moderator/Coordinator: Tripti Vashisth
University of Florida, Lake Alfred, GA

Coordinator: Shehbaz Singh
Apio Inc., Guadalupe, CA

**Objectives:**
1) Take a closer look at the horticulture industry in India (research and development and commercial horticulture industry).
2) Promote research and development and private sector enterprise partnership for successful application of new technology.
3) Create a sustainable Indian model of farm-to-market for a sustainable Indian horticulture industry.

**Description:** India is one of the leading producers of horticultural crops, however the production practices, harvest management system, and farm to market cold chain is still in the evolving stage. As India progresses into the 21st century with more than a billion people to feed and the World has to feed 9 billion by 2050 there is an urgent need for a United States–India horticulture partnership. Therefore, this workshop will be focused to overview horticulture industry of India, research and development to improve production and quality of specialty crops, and the strategies for sustainable horticulture industry as well as potential of partnership between horticulture industry of India and the United States.

8:00–8:05 AM

**Perspective of India and U.S. Horticulture Industry**

Ajay Jha*
Institute for Global Agriculture & Technology Transfer (IGATT), Fort Collins, CO

8:05–8:10 AM

**Perspective of India and U.S. Horticulture Industry**

Shehbaz Singh*
Apio Inc., Guadalupe, CA

8:10–8:35 AM

**Cluster Horticulture Farming and Value Chain Model in India**

Arjun Singh Saini*
Government of Haryana, Chandigarh, India

8:35–9:00 AM

**Role of Research in Promoting Indian Horticulture Industry**

Bhimanagouda Patil*
Texas A&M University, College Station, TX

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

9:00–9:30 AM

Rise of Horticultural Industry in India Due to Advancement in Food Science and Technology

Rakesh Singh*
University of Georgia, Athens, GA

(CEU Approved)

Workshop—Teaching and Researching within the Field of Urban Horticulture

Sponsor: Human Issues in Horticulture Working Group

Coordinator: Tina Waliczek
Texas State University, San Marcos, TX

Objectives: Identify and explore the various areas of teaching and research within Urban Horticulture, as well as to identify tools for developing a course to offer within the curriculum.

Description: In the wake of urbanization and technological advances, public green spaces within cities are disappearing and people are spending more time with electronic devices than with nature. This workshop will explore the importance of horticulture to the lives, health, and well being of urban populations. Topics will be explored through presentations from contributors to a new textbook, Urban Horticulture. These experts in research and practice from across the United States will discuss the history, importance, and benefits of selected topics in urban horticulture. The workshop and book examine types of public and private communities as well as state and federal programs to promote urban horticulture, including their history, management and administration, programming, evaluation, funding, and the benefits they provide to individuals and communities. The use of the book as a resource to develop and integrate an Urban Horticulture course into the curriculum and/or as an interdisciplinary option will be discussed.

8:00–8:15 AM

Teaching and Researching within the Field of Urban Horticulture

Tina Waliczek*
Texas State University, San Marcos, TX

8:15–8:30 AM

An Introduction to Urban Horticulture

Jayne Zajicek
Texas A&M University, College Station, TX

Tina Waliczek*
Texas State University, San Marcos, TX

8:30–8:45 AM

Children and Nature in the Urban Environment

Carolyn Robinson*
Auburn University, Auburn, AL

8:45–9:00 AM

Community Gardening

Tina Waliczek*
Texas State University, San Marcos, TX

9:00–9:15 AM

Urban Greening

Amy McFarland*
Grand Valley State University, Allendale, MI

(CEU Approved)

Workshop—Pioneers of Pomology

Sponsor: American Pomological Society

Moderator/Coordinator: Marvin Pritts
Cornell University, Ithaca, NY

Objectives: Describe the scientific contributions of early North American pomologists, present their unique and lasting impacts on the world of horticulture, and provide current pomologists with aspirational role models for our own work.

Description: Scientific progress is built upon the efforts of those who have come before us, and through their experimentation and discoveries, our own work advances. This is certainly true of early pomologists who applied discoveries in genetics, physiology and plant development to improve the germplasm and production systems that help supply the world with flavorful and nutritious fruits. Marshall Wilder, Ulysses Hedrick, Elizabeth White, Frederick Coville, George Darrow, Paul Shephard, and Wilfred Brierley were seven such individuals who made a lasting impact on North American horticulture. Even though buildings, cultivars and American Pomological Society awards are named after them, many pomologists are not familiar with their work.

8:00–8:15 AM

Paul Howe Shepard: A Man Dedicated to Fruit, Fun, and Service

Michele Warmund*
University of Missouri, Columbia, MO

8:15–8:30 AM

The Pioneering Horticulturist Marshall Pinckney Wilder

John Clark*
University of Arkansas, Fayetteville, AR

8:30–8:45 AM

Elizabeth White and Frederick Coville—Domesticators of the Highbush Blueberry

Mark Ehlenfeldt*
USDA-ARS, Marucci Center for Blueberry & Cranberry Res. & Ext. Lab, Chatsworth, NJ
skills critical to meeting demands of the industry. Despite a rigorous focus on technical or theoretical knowledge, identification and development of soft skills in students may often be overlooked or not fully developed in graduates from post-secondary academic programs. Proper identification and focus on the development of these skills is critical to student success and the ability of academic programs to prepare tomorrow’s leaders for needs of the industry.

**Poster Peer Review: What Makes an Effective Scientific Poster?**

Alex Rajewski*
University of Georgia, Athens, GA

The publication and presentation of research findings are key skills in the modern scientific community, but many graduate students and rising young scientists often lack the skills to effectively convey their research findings to a larger audience. Throughout graduate school and during the peer review process for manuscript publication, many scientists are given insightful and critical feedback to improve their skills in long-form writing. More often neglected, however, is the improvement of skills necessary to concisely and visually present complex results and conclusions in the form of scientific posters. Such poster sessions are common events at scientific conferences and symposia. These poster sessions and the accompanying short presentations by their authors allow young scientists to very effectively engage with their audience and deliver the results and conclusions from research projects. In the absence of a formal review process or information on proper design, many posters are inaccessible or ineffective, and are unfortunately overlooked despite containing compelling results. In this workshop session, we open several example scientific posters to audience critique and then deconstruct them to show what attributes make some posters engaging and appealing, while other posters remain tedious and ineffective. We will also work collaboratively to design a poster from a hypothetical research project in order to apply the results of our discussion.

**How to Enhance Student Soft Skills in an Online Class?**

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

Development of course content and assignments focused on basic horticultural knowledge and theory (hard skills) in an online setting is relatively straightforward and uncomplicated. However, it is slightly more challenging to improve students’ soft skills like communication, problem solving, critical observation, and professionalism in an asynchronous online classroom environment. To address this challenge, a set of etiquette rules were developed and implemented in online horticultural courses to set a professional tone. Assignments were then developed as challenge questions that focused on having students solve complex horticulture problems through written or oral submissions. Students were given data from simple experiments and asked to analyze and interpret the data. The recent addition of an online scholar’s ignite assignment has turned each student
During 2014 and 2015, a faculty task force defined competencies for career success. This concern comes from feedback from employers, internship supervisors, and graduate programs. Basically, we are doing a good job of teaching and training students (academically and technically), but our graduates require greater training in communications, critical thinking, problem solving, and leadership/management. These are often called “soft skills,” but we felt that because their long-term importance, these are “career skills.” The College of Agriculture and Life Sciences (CALS) has tackled this problem. Although our college graduates are technically competent, there is concern that they are insufficiently trained in some broader skills required for career success. This concern comes from feedback from employers, internship supervisors, and graduate programs. Basically, we are doing a good job of teaching and training students (academically and technically), but our graduates require greater training in communications, critical thinking, problem solving, and leadership/management. These are often called “soft skills,” but we felt that because their long-term importance, these are “career skills.” The College of Agriculture and Life Sciences (CALS) has tackled this problem. During 2014 and 2015, a faculty task force defined competencies for our graduates and vetted them through College faculty and more than 50 companies. Each degree-granting unit in the college is currently working to determine how these competencies can be incorporated into our curricula. Our approach is to incorporate competencies into existing courses (or replace existing courses with new ones) so as to avoid increasing the number of required credit hours for graduation and time to degree. We are asking each department to do so in a way to give students multiple opportunities to hone each of the competencies (i.e., incorporate skills into two or more courses). The CALS Student Career Skills Competencies are divided into three categories: 1) Communication Skills, 2) Critical Thinking/Problem Solving Skills, and 3) Leadership/Management Skills. Each category may have sub-categories, for instance, Communications Skills are divided into 1) written and electronic competencies, 2) verbal competencies, and 3) integrated competencies. As an example of competencies, under our Critical Thinking/Problem Solving Skills category, we want students to be able to: 1) define the problem; 2) gather relevant information; 3) formulate a solution; 4) take action; and 5) reflect and evaluate, with a focus on learning and improvement. Under each competency we define what we think an Unacceptable Level, our target Exit Level, and an Advanced Level for achieving the competency. We are presently compiling information on how students are given opportunities to develop these competencies both inside and outside of the classroom. The idea is that not every course or club or activity must cover all of these competencies, but that students have opportunities over their College career to achieve all of these competencies.

11:35–11:45 AM

Discussion

(CEU Approved)

Workshop—Impact of Rootstocks on Mineral Nutrition

Sponsor: Pomology Working Group
Moderator: Gregory Peck
Cornell University, Ithaca, NY

Coordinators: Esmaeil Fallahi1, Stefano Musacchi2, and Elina Coneva3
1University of Idaho Parma REC, Parma, ID; 2Washington State University, Wenatchee, WA; 3Auburn University, Auburn, AL

Objectives: During this workshop we will explore the influence of rootstocks on the uptake and availability of mineral nutrients in tree-fruit crops. The objective is to inform ASHS attendees about the latest advances in understanding the physiological and genetic mechanisms that control rootstock performance. Speakers will also address the impact of the soil-root and rootstock-scion interfaces. Presenters will discuss novel tools and advances in production recommendation that can be implemented by tree fruit producers.

Description: Over the past few decades there have been tremendous increases in tree-fruit orchard productivity. New rootstock genotypes have played a crucial role in these advances and have allowed for the development of highly efficient orchard production systems that integrate shorter tree heights with increased light capture orchard systems and greater planting densities, all while improving crop quality. Our understandings of the physiological and genetic mechanisms that allow rootstocks to be highly productive are tied to their ability to uptake and translocate minerals from the soil. Through this workshop, we will delve into the current research on the relationship between rootstock genotypes and mineral nutrition of fruit trees. Both applied and basic research studies will be presented.

1:45–2:05 PM

The Influence of Apple Rootstock Genotypes on the Cultivar Tree Performance, Productivity, Fruit Quality, and Mineral Nutrition

Esmaeil Fallahi*
University of Idaho Parma REC, Parma, ID

Stefano Musacchi
Washington State University, Wenatchee, WA

Lee Kalcsits
Washington State University, Wenatchee, WA

Bahar Fallahi
University of Idaho Parma REC, Parma, ID

An asterisk (*) in front of a name indicates the presenting author.
Bahman Shafii  
University of Idaho, Moscow, ID

The increasing world population and decreasing suitable land and water require significant increases in the fruit productivity and quality. One strategy is through the establishment of high-density orchards using size-controlling rootstocks. Rootstocks can affect a range of pomological characteristics of the scion cultivar. The objective of this research was to study the long-term impact of several rootstocks on precocity, yield, and fruit quality attributes and leaf mineral nutrition of the scion cultivars through different projects over several years. Rootstocks included standard commercial cultivars (M-9, Bud-9, etc.), newly released Geneva cultivars and other test rootstock genotypes. ‘Aztec Fuji’ trees on 70-20-20, B.67-5-32, CG.4004, CG.3001, and PiAu5111 had the largest trunk cross sectional area (TCSA) but those on B.7-20-21 and B.71-7-22 had the smallest TCSA. Trees on G41N, 935N, and CG4004 often had high yields, but those on PiAu990 and B.71722, and B.7-20-21 had the least production. Trees on CG.4003 and G11 were among the most yield efficient (yield in kg/TCSA) and crop efficient (fruit no/ TCSA) trees. Trees on B.7-20-20, and PiAu990 were among the least yield-efficient trees. Trees on G.41N, and CG3001, CG.4004 often had the largest fruit while those on B.7-20-21, CG.4003, and PiAu990 had smallest fruits. Fruit from trees on B.7-20-21 had the highest soluble solids concentration (SSC) and firmness because of their smallest size. Trees on B.7-20-20 were among those with the least color, SSC, and firmness among trees on all rootstocks. Fruits on G11N and G11TC had more advanced starch degradation pattern (SDP) while those on CG2034 and CG.5087 had the lowest SDP than those on other rootstocks. Rootstocks affected apple leaf mineral concentrations. ‘Gala’ trees on more vigorous rootstocks such as G30 had higher leaf K. Leaf sampling for mineral analysis in trees on dwarf trees could be taken earlier than those on vigorous ones. Rootstocks also influence the fruit mineral nutrition. Fruit with higher nitrogen and lower calcium was rootstock dependent and also associated with less color development and poor storage life. Rootstocks substantially affect important horticultural traits that impact overall tree productivity, quality and the ability to store that fruit. As more rootstock cultivars become available commercially, it will be critical to identify the rootstocks that are the most compatible with major commercial apple varieties to better guide nursery propagation efforts and industry planting strategies.

2:05–2:25 PM

Breeding Stone Fruit Rootstocks for High-efficiency Orchards

Gregory Reighard*  
Clemson University, Clemson, SC

Productivity of deciduous fruit orchards (such as apple) were revolutionized by size controlling rootstocks in the early 20th century, which significantly increased fruit production at the expense of vegetative growth and gave rise to labor efficient training systems. These apple rootstocks were further improved by breeders at the end of the 20th Century to be tolerant of diseases, insects, and edaphic conditions—including replant problems. In contrast, rootstock advancements for stone fruit had been hindered due to a lack of productive, size-controlling rootstocks that could be efficiently propagated. The advent of new public and private breeding programs and the rapid availability of genomics and propagation techniques/facilities has produced many new *Prunus* hybrid rootstocks for testing and eventual adoption by commercial stone fruit growers. Size-controlling cherry rootstocks have led the way with the Gisela®, Maxma®, and Krymsk® hybrids in commercial production and others like the WeiGi and Michigan State series in the testing stage. Peach, nectarine, and plum also have many promising rootstocks such as the Krymsk®, Rootpac®, and Controller™ series currently being widely tested or planted. Others, like Viking™, Guardian™, and MP-29, have been effective for replant and other pest problems. Fewer size-controlling rootstocks are available with known compatibility with apricot but some of the peach or plum rootstocks may have potential. Gene discovery and mapping among the *Prunus* genomes has provided information on genes for nematode and fungal resistance, nutrient uptake on calcareous soils, drought, salinity, bacterial canker syndrome, hydraulic conductivity (growth control), and root architecture that serves as a valuable tool to use in marker-assisted selection for important horticultural and disease traits. The incorporation of some of these genes into new rootstock cultivars and their resultant phenotypes will be highlighted as to how they have or can increase production efficiency of stone fruit orchards.

2:25–2:45 PM

Genetic Control of Mineral Uptake Correlated to Fruit Quality in Apples

Gennaro Fazio*  
USDA ARS, Geneva, NY

Michael A. Grusak  
USDA-ARS, Houston, TX

Terence Robinson  
Cornell University, Geneva, NY

A principal function of root systems is to forage for mineral nutrients in the soil and move them into different parts of the plants including the canopy where they are used in plethora of biological functions including fruit production. Grafted root systems allow the discernment of root (rootstock) dependent traits from scion dependent traits by joining genetically different plant parts in a composite tree system where variation that may be cause by intrinsic canopy traits may be eliminated by using the same genetic stock as the canopy (scion) and genetically different root systems as the rootstocks. We utilized field planted ‘Brookfield Gala’ trees grafted onto a replicated full sibling population of apple rootstocks from parents ‘Ottawa 3’ and ‘Robusta 5’ and measured mineral nutrient concentration for potassium (K), sodium (Na), phosphorus (P), calcium (Ca), copper (Cu), sulfur (S), zinc (Zn), magnesium (Mg), nickel (Ni), and molybdenum (Mo) in fruit and leaves during two consecutive growing seasons. Significant genotypic mean correlations were

An asterisk (*) in front of a name indicates the presenting author.
detected between years in pairs of same mineral concentration values (e.g., Pearson correlations between leaf K in 2013 and leaf K in 2014 was 0.65 and \( P < 0.0001 \)) and between fruit and leaf values for same mineral per year data. Quantitative trait loci analysis (QTL) revealed several loci positions were the same between years, including K on linkage group (LG) 5 and 11, leaf P on LG 5, 11, and 16. Additional QTLs were discovered in single year data for Ca, Cu, Mg, Na, S, Zn, and N. Fruit quality parameters (soluble solid content, flesh firmness, and red peel color) were measured in 2013. Significant correlations were detected between soluble solids and fruit Ca (–0.35, \( P = 0.0001 \)), soluble solids and fruit Cu (0.4226, \( P < 0.0001 \)), red peel color and fruit Mg (–0.29, \( P = 0.0017 \)), firmness (–0.26, \( P = 0.0051 \)). Multivariate two-way clustering grouped fruit Zn and Ca with peel color and fruit N and S with soluble solids and flesh firmness. Our initial analyses on the genetic effects rootstocks have on scion fruit quality reveals complex relationships among nutrients and fruit quality characteristics. We hope that additional analysis of this and other datasets will provide a genetic roadmap for identifying existing and breeding for new rootstocks that increase fruit quality.

2:45–3:05 PM

**Soil Microbial Mediation of Mineral Uptake By Apple Rootstocks**

Gregory Peck*
Cornell University, Ithaca, NY

Ashley A. Thompson
Virginia Polytechnic Institute & State University, Alson H. Smith AREC, Winchester, VA

Apple (*Malus xdomestica*) rootstocks confer beneficial traits, including mature tree size, precocity, and pest and disease resistance. The soil microbiome likely mediates some of these traits. Evidence suggests that carbon-based soil amendments, such as composts and mulches, increase crop growth by reducing pathogenic organisms and enhancing microbial activity. In previous work, we found that the soil microbiome can be manipulated by weed management and fertilizer inputs used for organic and integrated fruit production systems. Several studies have shown that soil microbiota influences apple replant disease incidence. In 2013, a pot-in-pot study was implemented to determine the impact rootstock genotype and fertilizer formulation have on apple tree growth and nutrient status, soil health, and microbial activity. An equivalent nitrogen rate was applied as five different fertilizer treatments: chicken litter compost, yard waste compost, calcium nitrate, chicken litter compost + calcium nitrate, and yard waste compost + calcium nitrate. There was also a non-fertilized control. Each fertilizer treatment was applied to five apple rootstock genotypes (‘Budagovsky 9’, ‘Malling 9’, ‘Geneva 41’, ‘Geneva 214’, and ‘Geneva 935’) grafted with Gala cv. Brookfield in a completely randomized design with four replicates. After three years, tree biomass was highest for ‘M.9’ and the compost compost + calcium nitrate treatments increased in tree biomass compared to the control. Overall, carbon-based fertilizers increased microbial biomass and activity and the amount of potentially mineralizable nitrogen. Molecular techniques used to “fingerprint” the microbial community, as well as to identify the richness, diversity, and specific taxa associated with the roots and soil of each treatment. Soil DNA was matched to known organisms, and provided an interpretation of how rootstock genotype and fertilizers affected the soil microbiome and thus plant growth and fruit production.
Designing Evaluation Metrics That Meet State Needs and Recognize Local Realities

Natalie Bungarner*
University of Tennessee, Knoxville, TN

Joseph Donaldson
University of Tennessee, Knoxville, TN

Some of the largest reporting challenges in consumer horticulture are the size and diffuse nature of our outreach and education efforts and our wide audience. Across the entire lawn and garden spectrum, we have a potential audience that encompasses a majority of residents in our states along with an employee and volunteer network of educators that numbers in the thousands. It is clear that our reach can often exceed our grasp in terms of gathering accurate impact data for consumer horticulture efforts. While the data collection struggle is real, it is necessary to move forward with impact reporting and assessment systems that are effective at a state and local level. These very issues are the current task underway in developing outcome indicators in Agriculture and Natural Resource (ANR) topic areas in Tennessee Extension. Workgroups of state and area ANR specialists together with county agents are developing outcome indicators that will form the basis for all local and aggregated statewide reporting. This case study will focus on our efforts in Tennessee to develop realistic and robust measures that work across our entire system. Main points of discussion and emphasis will be balancing assessments that can be feasibly integrated into the wide range of local activities and used by varied personnel while being appropriate for statewide reporting; showing the public value of Extension consumer horticulture programs; and examples of effective outcome measurement.

Exploring Economic Impacts of Educational Programming for Sustainable Residential Landscapes: A Literature Review

Charlotte Glen*
North Carolina State University, Pittsboro, NC

Gary Moore
North Carolina State University, Raleigh, NC

Koralalage Sunil Upali Jayaratene
North Carolina State University, Raleigh, NC

Lucy Bradley
North Carolina State University, Raleigh, NC

A summary of the literature on the economic impacts of consumer horticulture identifying effective strategies and gaps where new strategies need to be developed will be presented.

Workshop

Designing Evaluation Metrics That Meet State Needs and Recognize Local Realities

Natalie Bungarner*
University of Tennessee, Knoxville, TN

Joseph Donaldson
University of Tennessee, Knoxville, TN

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A summary of the literature on the economic impacts of consumer horticulture identifying effective strategies and gaps where new strategies need to be developed will be presented.
Challenges encountered by the fresh produce industry.

More than 9 million cases of foodborne illnesses with identified etiology are reported annually in the US and include severe outbreaks attributed to Cyclospora cayetanensis. In 2013 more than 630 cases of cyclosporiasis were associated with consumption of imported salad mixes in Iowa and Nebraska and with cilantro in Texas. In 2014, more than 300 cases of cyclosporiasis were associated with imported cilantro from Mexico, and in 2015, 546 cases of Cyclospora infection in 31 states were reported. Epidemiological and traceback studies linked some of the cases reported in Texas, Georgia, and Wisconsin with cilantro imported from Puebla, Mexico. Cyclospora can enter the food production system when human feces are deposited into the agricultural environment. At that point, the edible parts of crops may be contaminated either directly or indirectly. Contamination of the crop may also occur during harvest when produce comes into contact with other contaminated surfaces. The challenges encountered doing research with parasites are quite different than those with bacterial pathogens. As a result, the past three outbreaks have pointed to the lack of critical knowledge and research associated with understanding how parasites interact with vegetable plants and tissues. In this presentation we will address the large Cyclospora outbreaks since the 1990s and the challenges encountered by the fresh produce industry.

The 10-year Anniversary of Intensive Field-level Fresh Produce Safety Programming in Arizona: What Works and What Doesn’t

Kurt Nolte*
University of Arizona, Yuma, AZ

In 2006, a group of California handlers of leafy greens established the Leafy Greens Products Handler Marketing Agreement (LGMA) in response to the E. coli outbreak that was attributed to spinach grown in the Salinas Valley. The spinach recall resulting from the outbreak, and the consequential lack of consumer confidence in the industry, had a disproportionate impact on produce farmers and handlers in California and Arizona, since nearly 89% of leafy greens sold in the United States come from these two states. A voluntary program, the LGMA has been widely accepted by the produce industry, grocers and foodservice firms. Arizona also adopted an LGMA and has been implementing the program since 2008. Although the LGMA is an agreement between produce shippers, many of its compliance requirements fall upon growers to implement, as it requires signatory members to source their leafy greens solely from growers found to be in compliance with a set of food safety provisions called “best practices.” The LGMA guidelines are technically voluntary, but because produce companies that purchase over 99% of Arizona’s leafy greens have committed to selling only products grown in compliance with the LGMA, the standard has essentially become mandatory for many Arizona farmers. The LGMA offered hope of a respite from private industry standards and the requirement that they comply with multiple standards in order to sell to multiple buyers. However, the food safety benefits to companies participating in the LGMA are unclear. No food safety protocol guarantees safe food, nor is it known where the contamination of the lettuce took place. For farmers, the expected gains from having one standard applied consistently across the leafy greens industry have not materialized. Some produce buyers who adopted the LGMA continue to enforce their own standards as well, requiring farmers to be audited for both. Small farm, conservation and wildlife groups are concerned about the stringent guidance on wildlife, noncrop vegetation, and water testing. These groups also worry that small and biodiverse farms are being forced to choose between market access and their biodiversity and conservation goals. In light of the national implementation of Food Safety Modernization Act (FSMA) guidelines, this presentation provides a specific overview of the Leafy Green Marketing Agreement as it relates to the ramifications of existing and proposed protocols, while recognizing that the one-size-fits-all approach may not be appropriate especially when identifying the diversity of farm sizes and production methods in the United States.

Workshop-Sensor-based Technology for Ecophysiological Research of Horticultural Crop Production Systems (CEU Approved)

Sponsor: Crop Physiology Working Group
Moderator/Coordinator: T. Casey Barickman
Mississippi State University, Verona, MS

Objectives: The objective of this workshop is to introduce how sensor-based technologies can be used in plant ecophysiological research for horticultural crop production systems.

Description: Plant ecophysiology is the study of how the environment, both physical and biological, interacts with plant physiological responses, such as plant growth, water relations, gas exchange, stress, and defense. In particular, it examines how the climate and nutrients affect the plant’s physiological processes and how plants respond to highly variable environmental conditions. In order to understand how the environment interacts with plant physiology, researchers have developed innovative new technologies for sensing the environment and plant health. Sensors are devices that measure physical properties and record quantitative information. For example, one type of soil sensing technology detects moisture indicating when to irrigate and could increase irrigation efficiency for horticultural crops. Although collecting sensor data can be easy, data are only useful if the sensors are properly calibrated, placed in the correct locations, and adjusted for environmental variables that can affect sensor performance.
An asterisk (*) in front of a name indicates the presenting author.

Workshop

10:30–11:00 AM

**Unlocking the Potential of Soil Sensor Data**

John Lea-Cox  
University of Maryland, College Park, MD  
Matthew Chappell*  
University of Georgia, Athens, GA

11:00–11:30 AM

**Arduino: A Low-cost Option for Automating Data Collection and Controlling Environmental Conditions**

Marc van Iersel*  
University of Georgia, Athens, GA

11:30 AM–12:00 PM

**A Review of Instruments and Approaches for Automated Measurement of Crop Water Status**

Bruce Bugbee*  
Utah State University, Logan, UT

(CEU Approved)

**Workshop—Washing Your Produce—Sanitizing Solutions**

Sponsor: Produce Quality, Safety, and Health Properties Working Group  
Moderator: Matthew Kleinhenz  
The Ohio State University-OARDC, Wooster, OH  
Coordinator: Annette Wszelaki  
University of Tennessee, Knoxville, TN

**Objectives:** 1) Provide educators with current options and best management practices for enhancing food safety postharvest. 2) Address compliance with NOP and FSMA standards in the postharvest arena. 3) Introduce participants to novel emulsified essential oil-based sanitizers that were recently evaluated as organic alternatives for washing produce.

**Description:** Food safety is of the utmost concern to the produce industry. Based on outbreak investigations, points of original contamination occurred during growing, harvest, packing or holding of produce on the farm. The root cause of many outbreaks has been linked to postharvest contamination. Postharvest water contamination, in particular, including water used for rinsing, washing, cooling, waxing, icing, or moving fruits and vegetables, can be quickly amplified by errors in postharvest management. Current regulations and guidance documents (EPA, USDA-NOP, FDA-FSMA) on appropriate postharvest handling, including washing and packing house sanitation, can be confusing to interpret and thus many times are not successfully implemented. Proper application of sanitizers can reduce the number of pathogens and prevent cross contamination in wash water and on food contact surfaces. The advantages and drawbacks of different sanitizers, intended use in growing operations or on surfaces, and management factors that influence the useful and adverse results of these sanitizers are rarely understood. The need for effective integration of regulations, such as the National Organic Program and the FSMA Produce Safety Rule, with best management practices for contaminated water and increased demand for mitigation steps represents a significant and reoccurring risk for the produce industry. We will discuss the integration of sanitizers into postharvest handling to meet FSMA and NOP requirements, as well as the evaluation of some novel sanitizers.

10:30–10:50 AM

**So Many Options, so Little Time: Selecting the Right Sanitizer for Your Operation**

Diane Ducharme*  
North Carolina State University, Kannapolis, NC

Using proper cleaning and sanitation practices is essential in maintaining produce quality and safety postharvest. Poor management at critical points in the flow of produce from field to market can magnify the potential for contamination to occur, remain and spread within any farming operation. The use of food grade sanitizers should be included in postharvest water as well as on food contact surfaces such as harvest containers, harvest knives, grading tables, sinks, and other equipment/tools that come in contact with produce. Sanitizing reduces the number of pathogens in these postharvest water applications, and prevents cross-contamination and the formation of biofilms; however, not all sanitizers are created equal. In this session, we will cover aspects you should consider when selecting a sanitizer and inherent differences among the efficacy of sanitizers when applied in a produce operation.

10:50–11:10 AM

**Hitting the Mark for Food Safety and Organic Production in Postharvest**

Annette Wszelaki*  
University of Tennessee, Knoxville, TN

Water disinfection and sanitation of equipment and food contact surfaces should be incorporated into every postharvest handling program, regardless of farm size or production method. Yet, growers often express confusion between the standards outlined in the National Organic Program (NOP) and the food safety standards defined in the Good Agricultural Practices (GAPs) or the Food Safety Modernization Act Produce Safety Rule. In addition to choosing a sanitizer that will be effective, organic growers must also ensure that the sanitizer they adopt is allowable and they must be aware of the specific application parameters of that sanitizer in organic systems. In this session, we will discuss how growers can be compliant with NOP Standards while also...
having a sound and robust food safety program for their farm.

11:10–11:30 AM

**Filling the Pipeline: Considerations for Novel Sanitizers in Organic Production**

Laurel Dunn*
University of Tennessee, Knoxville, TN

Washing fruits and vegetables postharvest removes debris and is necessary to prepare many commodities for market; however, this step has also been shown to be a primary point of contamination if antimicrobials are not used in the wash water. While chlorine and peroxyacetic acid are approved and effective, many organic producers seek alternatives. The antimicrobial effectiveness of essential oils, such as clove bud oil (CBO) and thyme oil (TO), have been recognized, but their hydrophobicity makes them difficult to implement in aqueous systems. Here we will discuss recent research evaluating the efficacy of self-emulsified alkaline-dissolved essential oils when tested in a produce washing system to control food-borne pathogens.

11:30–12:00 PM

**Panel Discussion with Speakers**

Diane Ducharme*
North Carolina State University, Kannapolis, NC

Laurel Dunn
University of Tennessee, Knoxville, TN

Annette Wszelaki
University of Tennessee, Knoxville, TN

In this session, we hope to engage the audience in discussion with the panel on postharvest water use.

(CEU Approved)


Sponsor: Growth Chambers and Controlled Environments Working Group

Moderators: Rhuaniito S. Ferrarezi¹, Alex Litvin², and Michael Martin³

¹University of the Virgin Islands, Kingshill; ²Iowa State University, Ames, IA; ³University of Georgia, Athens, GA

Coordinators: Shuyang Zhen, David Gianino, and Geoffrey Weaver
University of Georgia, Athens, GA

**Objectives:** 1) To explore the basic functions of Arduino microcontrollers. 2) To explain the basic programming structure. 3) To give participants hands-on experience connecting sensors, displays, and relays. 4) To discuss how Arduino microcontrollers can be used to control environmental conditions. 5) To show how these microcontrollers can be used for automated data collection and display.

**Description:** Arduino microcontrollers are low-cost open-source devices that can be used to build systems to automate data collection and to control experimental conditions (such as soil moisture, temperature, CO₂, and light). This workshop will give participants an introduction into the use of Arduinos. The workshop will cover programming, wiring, and data collection and display. Participants will learn how to use sensors with a serial or voltage output signal and how to use the data coming from these sensors to control external devices (such as irrigation valves) using relays. The workshop will also cover how to write data to an SD card and how to display data on a screen attached to the Arduino. There will be a display of various Arduino-based systems that measure and control light levels, irrigation, and temperature. Because of the hands-on nature of the workshop, all participants will need their own hardware and bring a laptop with the free Arduino software installed.

**Arduino: Building and Programming Simple Measurement and Control Systems**

Rhuanito S. Ferrarezi*
University of the Virgin Islands, Kingshill

Alex Litvin
Iowa State University, Ames, IA

Michael Martin
University of Georgia, Athens, GA

Shuyang Zhen
University of Georgia, Athens, GA

David Gianino
University of Georgia, Athens, GA

Geoffrey Weaver
University of Georgia, Athens, GA

Marc van Iersel
University of Georgia, Athens, GA

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Workshop

Workshop—Asserting the Relevancy and Impact of Postharvest Programs Around the World

Sponsor: Postharvest Working Group
Coordinator: Mark Ritenour
University of Florida, Fort Pierce, FL

Objectives: To explore postharvest research and outreach activities in terms of perceived benefits to funding agencies, policymakers, industry stakeholders, and society in general, and to adopt practices that not only solve postharvest problems, but also communicate the value of postharvest programs to these diverse groups.

Description: Despite the fact that postharvest fruit and vegetable losses continue to be high (often 30% to 60%), even in developed countries, and that there have been concerted efforts to publicize the needs and opportunities for postharvest research and outreach activities to mitigate these losses, there is a perceived decline in interest in postharvest research and outreach activities from funding agencies, policy makers, industry stakeholders, and society in general. Are postharvest issues perceived to be as relevant to these groups as they were in past decades? If so, what are the postharvest issues that resonate most with these groups? If not, how might postharvest research, extension and teaching professionals better communicate the value and impact of postharvest issues to these groups? This workshop will discuss these issues to not only solve postharvest problems, but also communicate the value of postharvest programs to these diverse groups.

1:45–1:50 PM
Introduction to the Workshop
Mark Ritenour*  
University of Florida, Fort Pierce, FL

1:50–2:15 PM
What’s “Hot” in Postharvest Research in the United States
Gene Lester*  
USDA–ARS/Quality and Utilization of Agricultural Products, Beltsville, MD

Food Security, which involves Climate Change, Water, and Food Waste and Quality, are the interrelated “hot areas” in Postharvest horticulture from a USDA-National Program Leader perspective. Food security—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 that impact food security 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 system that 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 that aid in food security.

2:15–2:40 PM
Postharvest Interventions for Sustainable Development of the Horticulture Sector in Lesser Developed Countries
David Picha*  
Louisiana State University, Baton Rouge, LA

Significant development of the non-traditional agriculture export sector has occurred in many lesser-developed countries during the last several decades. High-value horticultural crops have been at the forefront of this sustained economic growth activity. Constraints to product quality have been overcome by training, technical assistance, and improved postharvest technology introductions, which have facilitated the arrival of consistent supplies of high quality products in the destination markets. Postharvest technology interventions have been a catalyst to the development of many individual fruit, vegetable, and cut flower sectors in countries not previously involved in horticulture crop export. Specific postharvest technology introductions necessary for international market competitiveness and sustained horticulture industry growth will be presented. Individual crop and postharvest technologies will be reviewed to include a diversity of temperate and tropical fruits, vegetables, and cut flowers in multiple regions of the world.

2:40–3:05 PM
Connecting Postharvest Research and Outreach Programs with Industry and Society
Mark Ritenour*  
University of Florida, Fort Pierce, FL

Advances in technology and handling techniques through postharvest research and training provided the foundation for expansion of fresh produce and cut flowers into many lucrative markets. By implementing such information and tools, companies thrived and the value of the work was abundantly evident. Is this still the case? This presentation will evaluate ways that postharvest researchers (both university and industry), Extension professionals, consultants, and educators continue connecting their work with current key issues, such as in providing safe, nutritious, and high quality products in a sustainable manner. It will also discuss traditional and novel ways the information and impacts of such work are being communicated with society.

An asterisk (*) in front of a name indicates the presenting author.
Many herbicides applied to crops or ornamental areas have the potential to persist in soil and to injure desirable vegetation or rotationally grown crops. This workshop will demonstrate the potential injury to herbaceous and woody horticultural plants from herbicide residues that drift off-target or carryover/persist in soil and other materials. The last part of the workshop will demonstrate how the EPA Drift Reduction Technology program encourages the manufacture, marketing, and use of spray technologies scientifically verified to significantly reduce pesticide drift. Initially, the focus of the program was on spray technologies used primarily for pesticide applications to row and field crops by ground or aerial application equipment, but there is hope to expand this program to include technologies for orchard and vineyard crops.

**The Potential for Injury to Horticultural Crops from Herbicide Carryover and Material Contamination**

Timothy Miller*
Washington State Univ, Mount Vernon, WA

Many herbicides applied to crops or ornamental areas have the potential to persist in soil and to injure desirable vegetation or rotationally grown crops. Active ingredients such as atrazine, halosulfuron, dichlobenil, and clomazone are just a few examples of herbicides with extended half-lives that, under certain conditions, may persist in soil for more than one growing season. Sometimes purposeful applications of selective herbicides have unintended effects upon sensitive horticultural plant species, as was recently observed by applications of aminocyclopyrachlor to residential turf in the Midwestern U.S., resulting in severe damage to nearby trees and shrubs. Clopyralid, picloram, and aminopyralid are similar auxinic herbicides that have been shown to not only persist in soil, but also to resist metabolism by microbes when treated plant residues are composted. Mandatory curbside recycling programs of lawn waste and grass clippings in Spokane, WA, in the early 2000s resulted in aminopyralid–contaminated compost that caused severe damage to backyard and commercial crops in Solanaceae, Asteraceae, and Fabaceae. In the late 2000s, aminopyralid was found in finished compost in northwestern Washington state that similar injured sensitive vegetable crops. Aminopyralid had been legally applied to forage and fed to cattle, but dairy operators failed to quarantine the manure and it entered the composting stream. In a subsequent greenhouse trial, aminopyralid residue as low as 10 ppb caused significant injury to pea, sunflower, and bell pepper seedlings. Label modifications by manufacturers have greatly reduced the likelihood of similar damage to horticultural crops from application of herbicide-contaminated compost, but local growers are advised to perform a bioassay using a sensitive plant species when they are unsure whether soil or compost contains potentially harmful herbicide residues.

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An asterisk (*) in front of a name indicates the presenting author.
Detached current year shoots were frozen in a controlled ultra-low freezer and evaluated. Significant decreases in cold hardiness, over species, occurred in shoots, eight months after BA of Roundup Original Max® and Roundup Pro®. The no wound/no herbicide control had the hardiest shoots, followed by the wound/no herbicide and wound/KleenUp Pro® which were not statistically different. On 2 Nov. 2011 (fall), and 25 June 2012 (summer), AquaMaster® (53.8% isopropylamine salt of glyphosate) and Roundup Pro® were sprayed over-the-top (OTT) or as BA applications, directed 2.5 in from crown/substrate union to simulate drift vs. a direct application on Syringa reticulata. Shikimic acid (SA) levels (as a real time biomarker for determination of plant exposure to glyphosate) were quantified by leaf tissue extractions and LC/MS/MS evaluations following treatments. SA levels in leaves following summer and fall + plus summer applications of Roundup Pro® OTT increased 17.5-fold and 10.2-fold, respectively, vs. the control, indicating a long-term carry-over effect on the SA pathway. Specific glyphosate formulations carry-over in the plant, result in long-term disrupting of the SA pathway, reducing cold hardness, and increasing frequency of bark cracking in susceptible species.

2:40–3:00 PM

**Defining Glyphosate and Dicamba Drift Injury to Field Pea, Dry Bean, and Potato**

Harlene Hatterman-Valenti*
North Dakota State University, Fargo, ND

G. Endres
North Dakota State University, Carrington, ND

B. Jenks
North Dakota State University, Minot, ND

M. Ostlie
North Dakota State University, Carrington

T. Reinhardt
North Dakota State University, Fargo, ND

A. Robinson
North Dakota State University, Fargo, ND

R. Zollinger
North Dakota State University, Fargo, ND

Herbicide spray drift is the most common complaint in relation to pesticide use in North Dakota. With the development of glyphosate-resistant crops and the quick conversion to these cropping systems, glyphosate was often the herbicide suspected for off-target injury. However, dicamba-resistant soybean and the adoption of this technology to combat glyphosate-resistant weed problems, may cause even more drift injury to off-target horticultural crops. Dicamba is known to be volatile and can remain in spray equipment if not cleaned properly, which may injure off-target plants during spraying operations. An overview of six simulated drift studies using glyphosate, dicamba, and mixtures of both herbicides on field pea (*Pisum sativum* subsp. arvense L.), dry bean (*Phaseolus vulgaris* L.), and potato (*Solanum tuberosum* L.) will be presented. All studies used three sub-lethal doses at 10-fold increments of glyphosate and dicamba, along with high, medium, and low doses of both herbicides mixed together. The highest dose for each herbicide did vary for the three crops due to sensitivity differences. Herbicide doses were targeted for the R1 stage with field pea and dry bean, and at tuber initiation for potato. Visual injury observations were made 10 and 20 days after treatment (DAT), while yields and grades were collected at the end of the growing season. For field pea, visual injury was relatively low ≤ 21% at 10 DAT and decreased by 20 DAT. Visual injury symptoms were greater for dry bean, especially when doses included dicamba. For potato, visual injury was greatest for doses that included dicamba, but were relatively low ≤ 13% at 10 DAT and increased two-fold or more by 20 DAT. Yield reduction compared to the untreated was greatest when doses included dicamba, regardless of the crop. Results suggest that drift injury potential to field pea, dry bean, and potato will be greater if a dicamba-resistant soybean crop is adjacent and upwind compared to a glyphosate-resistant crop.

3:00–3:20 PM

**Effect of Simulated Drift on Various Plant Species**

Travis Gannon*
North Carolina State University, Raleigh, NC

Much recent research has focused on various environmental conditions and sprayer setup that impact pesticide spray drift potential. Off-target crop injury via spray drift can be more problematic in specific areas due to the close proximity of applications to the wide array of crops grown in certain geographies. Although information is available regarding management practices to minimize pesticide off-target movement, there remains potential for spray drift; consequently, pesticide zero-drift tolerances are not a feasible expectation. Recently, verbiage on pesticide labels regarding drift has been revised to be less subjective for applicator interpretation; however, many labels are vague in describing avoidance of drift into sensitive areas, including bodies of water, wetlands, endangered species habitats, and non-labeled agricultural crop areas including horticultural crop production areas. Much of the research has focused on synthetic auxin mimic herbicides including 2,4-D and dicamba. Indaziflam is a new PRE herbicide for control of annual grass and broadleaf weeds in numerous settings including managed roadsides, railroads, and non-croplands, many of which are in close proximity to horticultural production areas. Greenhouse research was conducted to evaluate the effect of PRE and POST simulated indaziflam or synthetic auxin (aminocyclopyrachlor), clopyralid + triclopyr, or aminopyralid spray drift on the growth of cotton, bell pepper, soybean, squash, tobacco, and tomato. Evaluated spray drift rates were 100%, 20%, 10%, 5%, or 2.5% of application rate and plant growth responses varied among herbicides and application timings.

An asterisk (*) in front of a name indicates the presenting author.
**Workshop—Methods and Opportunities in Rhizosphere Research and Management**

**Sponsor:** Root Growth & Rhizosphere Dynamics Working Group

**Moderator:** Jeffrey Norrie  
Acadian Seaplants Limited, Dartmouth, NS, Canada

**Coordinator:** J. Pablo Morales-Payan  
University of Puerto Rico, Mayagüez Campus, Mayaguez, PR

**Objectives:** The objective of this workshop is to share with the audience information and methodology on root growth and rhizosphere research.

**Description:** The rhizosphere is an essential but sometimes overlooked component of crop systems. This workshop is designed to present information on new research and monitoring techniques for rhizosphere studies, breeding of root traits, and manipulation of the rhizosphere with exogenous growth substances and/or management practices to enhance crop performance.

2:00–2:25 PM

**Using a Non-contact Electromagnetic Induction Sensor to Measure Moisture Extraction By Root Systems of Sweetpotato Genotypes**

Arthur Villordon*
Louisiana State University Ag Center, Chase, LA

Don LaBonte  
Louisiana State University AgCenter, Baton Rouge, LA

We describe the use of an electromagnetic induction (EMI) sensor for proximal measurements of apparent electrical conductivity (ECa) to infer soil drying profiles in the root zone of sweetpotato breeding lines. Our hypothesis was that differential ECa readings during the storage root bulking stage (25–35 days after planting) was associated with variation in soil water depletion as a result of genotype-dependent variation in root development. We used a Geonics EM38 MK2 (Geonics Limited, Ontario, Canada) EMI sensor in horizontal dipole mode. In this study, we measured the ECa of 1,006 individual five-plant plots that were 1.5 m wide and 1 m long. The sensor was suspended about 5–10 cm above the canopy and individual plot measurements were obtained. The georeferenced data set was converted into a point shapefile using QGIS (v.2.10; Open Source Geospatial Foundation Project) and subsequently transformed into a raster layer using the inverse distance algorithm with default settings. The study area comprised 0.57 ha. After 120 days, the plots were harvested using a mechanical harvester and individual plots (genotypes) were selected based on predefined selection criteria. The location of each selected plot (SP) was georeferenced using a GPS-enabled Archer 2 ruggedized field computer (Juniper Systems, Logan, UT). GIS-based analysis indicated that 69% of the selections were obtained from plots that showed relatively low ECa (4.2–9.7), while the remainder were obtained from plots that showed relatively high ECa (12.27–14.7). These findings demonstrate the potential for the EMI-based approach to provide feedforward information about root development at the critical root bulking stage that can be incorporated into selection decisions at harvest. The raster model also showed a distinct moisture gradient in the field, indicating possible confounding effects associated with field variability. Such information can be used to reduce within-field variation, thereby improving selection efficiency.

2:25–2:50 PM

**Breeding for Rhizosphere Traits: From Theory to Practice**

Gerardo H. Nunez*  
University of Florida, Gainesville, FL

2:50–3:15 PM

**Priming the Rhizosphere with Natural Products: Ascophyllum Extracts**

Jeffrey Norrie*  
Acadian Seaplants Limited, Dartmouth, NS, Canada

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An asterisk (*) in front of a name indicates the presenting author.
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Part 2: Abstracts of Oral and Poster Presentations

Oral Presentations

Monday, August 8, 2016

Oral Session—Viticulture and Small Fruits 1

Moderator: Shengrui Yao
New Mexico State University Sustainable Agriculture Sciences Center, Alcalde, NM

1:00–1:15 PM

Effective Pollination Period of ‘AU Golden Sunshine’ (Actinidia chinensis) and ‘AU Fitzgerald’ (A. deliciosa)

Ashley K. Brantley
Auburn University, Auburn, AL
James Spiers*
Auburn University, Auburn, AL
Andrew B. Thompson
Alabama Cooperative Extension Service, Ozark, AL
Elina Coneva
Auburn University, Auburn, AL
J. Raymond Kessler
Auburn University, Auburn, AL
Amy Wright
Auburn University, Auburn, AL

The marketable yield and profitability of kiwifruit production is closely associated with successful pollination. Commercial kiwifruit production often involves much effort to enhance pollination due to the inherent difficulties associated with functionally dioecious plants with flowers that do not produce nectar. Determining the length of time that female flowers can be successfully pollinated would aid management decisions. Therefore, the purpose of this research was to determine the effective pollination period (EPP) for Actinidia chinensis ‘AU Golden Sunshine’ and A. deliciosa ‘AU Fitzgerald’. In 2013, 30 female flowers (n = 30) that had been previously isolated/bagged for each cultivar were hand pollinated each day by direct flower-to-flower contact with the male pollinizer, and re-bagged to prevent open pollination. ‘AU Golden Sunshine’ flowers were pollinated 1, 2, 3, 4, and 5 days after anthesis (DAA) and ‘AU Fitzgerald’ flowers were pollinated 1, 2, 3, 4, 5, and 6 DAA. Anthesis was considered the day the flower opened. In 2014 and 2015, the same procedures were followed as the year before but with slight modifications: 32 female flowers (n = 32) were hand pollinated with harvested male pollen each day with a camel hair brush and the flowers were pollinated for 1, 2, 3, 4, 5, 6, and 7 DAA. Results for the EPP determination of ‘AU Golden Sunshine’ suggests that for successful fruit set, flowers should be pollinated within 5 to 6 DAA. However, fruit with the greatest size, weight and seed number was realized when pollinated within 3 DAA for years 1 and 2 and within 5 DAA for year 3. For ‘AU Fitzgerald’, fruit set declined at 5 DAA for the first year (2013) suggesting that the EPP was 4 DAA. In the second year (2015), fruit set remained consistently high over the 7-day period, though fruit weight, size, and seed number declined 5 DAA. Flower production and fruit set for ‘AU Fitzgerald’ was prolific in 2015, suggesting that the EPP was affected by the biennial nature of the species.

1:15–1:30 PM

Revitalizing the Local Strawberry Industry through Needs Assessment and New Varieties

William Hlubik*
Cooperative Extension of Middlesex County Rutgers New Jersey Agricultural Experiment Station, North Brunswick, NJ
Peter Nitzsche
Cooperative Extension of Morris County, Rutgers New Jersey Agricultural Experiment Station, Morristown, NJ
Gillian Armstrong
Cooperative Extension of Middlesex County, Rutgers New Jersey Agricultural Experiment Station, North Brunswick, NJ
Matthew Milburn
Cooperative Extension of Middlesex County, Rutgers New Jersey Agricultural Experiment Station, North Brunswick, NJ
Gojko Jelenkovic
Rutgers Department of Plant Biology and Pathology, New Brunswick, NJ

The Rutgers New Jersey Agricultural Experiment Station strawberry breeding program team developed a survey to determine the value and needs of small fruit growers. Formal surveys were conducted in person for 60 farmers growing 103.3 acres of strawberries. The survey revealed that 80% of the growers ranked weather, variety selection/availability, marketable yield, insect, disease and weed pests, and deer damage as the greatest challenges to growing small fruit on their farm. Eighty-six percent of respondents reported that growing small fruits helps to attract and keep customers coming to their markets. Fifty-three of the 60 respondents were growing strawberries and reported the following: 85% ranked flavor as one of the most important characteristic when selecting strawberry varieties for their farm; 83% ranked yield as important; and 78% reported size as an important factor in variety selection. Eighty-five percent of the strawberry growers surveyed sell directly to customers through farm stands, community supported agriculture, pick-your-own, and community farmers markets. Over 39% of those surveyed growing conventional strawberries plan to increase their acreage of strawberries over the next year. The strawberry breeding program team released the Rutgers Scarlet™ in 2015 to provide

An asterisk (*) following a name indicates the presenting author.
local growers with new strawberry varieties with outstanding flavor. The new variety was developed for the climate and growing conditions of the Eastern region of the United States. Since its release over 360,000 Rutgers Scarlet™ strawberry plants have been distributed to growers in 22 states. Members of the NJAES strawberry breeding team were interviewed by local and regional television, radio, newspaper and internet media outlets which stimulated public interest in strawberries and increased visits to farms statewide to purchase fresh strawberries.

Specified Source(s) of Funding: Specialty Crops Block Grant

1:30:1:45 PM

Uptake of Foliar Nutrients Applied to Productive Southern Highbush Blueberry (V. corymbosum, Interspecific Hybrids) Emerald

Erick Smith*

The University of Georgia, Tifton, GA

Jeremy Taylor

The University of Georgia Extension, ANR Agent, Lanier/Clinch Counties, Lakeland, GA

Foliar applications of nutrients are used to correct deficiencies, improve fruit quality, and amend nutrient programs. However, many growers apply nutrients foliarly to blueberry plants, although the efficacy of foliar applications is not well demonstrated. The objective of this study was to determine uptake of nutrients applied foliarly to healthy southern highbush blueberry ‘Emerald’. In 2015, two applications of chelated [Albion Metalosate Crop-Up (AMC), Clearfield, UT; Mg: 0.05%, B: 0.025%, Cu: 0.25%, Mn: 2.50%, Fe: 0.25%, Zn: 1.25%] and sulfate salt chemistries [R.W. Griffin Industries (RWG), Douglas, GA; Mg: 2.0%, B: 0.1%, Cu: 0.25%, Mn: 1.0%, Fe: 2.0%, Zn 1.0%] were applied on 29 May and 18 Aug at 4.7 L·ha⁻¹ and 27.8 L·ha⁻¹, respectively. For each treatment, an application without and with a non-ionic surfactant was included [Loveland Products LI 700 (L), Greeley, CO]. The 29 May application was after harvest and before hedging on 8 June. The treatments were sampled 3 and 10 d after application (DAA). The leaves sampled were fully expanded, from new growth, washed with 0.1% solution of non-phosphate soap, dried, and sent to an agricultural testing lab (Waters Lab, Camilla, GA). Chlorophyll (Opti-Science, Hudson, NH) indices were measured at each leaf sampling. Shoot length and count were measured after 28 Aug. Both Mg and S were not deficient in plants and only AMC/L had 17% more Mg on 8 June by 10 DAA. All other treatments were statistically equivalent to the untreated plants by 10 DAA. The only micronutrient that was deficient in the untreated plants was Fe (≤ 50 ppm); Fe was lowest (45.1 ppm) on 21 Aug. The micronutrients applied generally showed higher concentrations when compared to the untreated plants at 3 DAA than 10 DAA. Applying a higher rate, the micronutrients increased foliar concentrations of Cu, Fe, Mn, and Zn at 10 DAA; however only RWG/L consistently increased nutrient levels at 47%, 37%, 21%, and 59%, respectively compared to the untreated plants. Chlorophyll indices were similar among treatments within each leaf sampling date except on 1 and 8 Jun when there was a 14% and 12% increase for AMC, respectively, relative to the untreated plants. Shoot length and count were suppressed in all the treatments with application of L. In conclusion, foliar macronutrients Mg and S are unwarranted for healthy ‘Emerald’. Both Fe and Cu showed efficacy as a sulfate salt or chelated compound and LI-700 showed inhibit growth.

Specified Source(s) of Funding: Specialty Sources(s) of Funding: Georgia Agricultural Commodity Commission for Blueberries (BLUE1504)

1:45–2:00 PM

Descriptive Analysis of Juice from Six Elderberry Cultivars

Michele Warmund*

University of Missouri, Columbia, MO

A study was conducted to quantify juice characteristics and to evaluate sensory attributes of juice from six elderberry (Sambucus spp.) cultivars using descriptive analysis. Fruit was harvested from a replicated trial including ‘Bob Gordon’, ‘Marge’, ‘Ocoee’, ‘Ozark’, ‘Wyldewood’, and ‘York’ planted at Mount Vernon, MO. ‘Bob Gordon’ and ‘York’ juices had the lowest hue values and were visually browner in color than samples of other cultivars. ‘Wyldewood’ and ‘York’ juices had the lowest total soluble solids and titratable acidity. Also, ‘Wyldewood’ and ‘York’ juices had higher pH values than samples from all other cultivars except for ‘Bob Gordon’. For sensory analysis, berries were heated to 80 °C for 5 minutes before pressing and sucrose was added to adjust each juice sample to 13 °Brix. Trained panelists identified 24 terms for descriptive analysis of elderberry juices. Elderberry juices were characterized by processed aroma and flavor, but varied in fruity, floral, sweet aromatics, bitter, sour, sweet, and anstringent flavors and bitter and sweet aftertastes. ‘York’ juice had relatively high intensity ratings for fruity, floral, sweet aromatics, and sweet flavors and lower ratings for bitter aftertaste as compared with those from other cultivars. Development of a formal lexicon for American elderberry with defined attributes provides a basis for future elderberry sensory research.

2:00–2:15 PM

Jujube, a Vitamin C Rich Fruit

Shengrui Yao*

New Mexico State University Sustainable Agriculture Sciences Center, Alcalde, NM

Robert Heyduck

New Mexico State University Sustainable Agriculture Sciences Center, Alcalde, NM

Jujube (Ziziphus jujuba Mill.) belongs to the Rhamnaceae family. It was domesticated from its wild relative-wild jujube (Ziziphus spinosa) in China and gradually become the current species Z. jujuba. Jujube cultivars have been imported into the United States since 1908. The vitamin C content of jujube fruit was estimated by fresh weight and 100 fruit basis and the results revealed that its vitamin C content was 73.13 mg/100 fruit and 52.3 mg/fresh weight. The vitamin C content of jujube fruit was high enough to meet the requirement of health. It was also stated that the vitamin C content of jujube fruit decreased with the increase of the number of the fruit on the tree. An asterisk (*) following a name indicates the presenting author.
is 4–10 times higher than orange. Jujube fruit is also known as natural vitamin C pills in China. The NMSU Alcalde Center started its jujube research and extension program in 2010. Now there are over 50 jujube cultivars at NMSU Alcalde. We have been evaluating jujube vitamin C content with a 2-6-dichlorophenol indophenol titration method since 2011. Among the 50 cultivars tested, their fruit vitamin C content ranged from 200–600 mg/100g fresh weight, higher than most fruit and veggies species, with ‘Youzaoo’ having the highest content at 858 mg/100 g fresh weight. Jujube vitamin C content varied slightly from year to year but each cultivar kept its vitamin C content relatively constant. ‘Shuimen’ always had the lowest and ‘Youzaoo’ had the highest vitamin C content among the cultivars tested. Most fresh eating cultivars like ‘Li’, ‘Li-2’, ‘Redland’, ‘Daguazao’, and ‘Dabailing’ were relatively low in vitamin C content while the drying cultivars were on the high end for vitamin C content. During the fruit ripening process, fruit vitamin C content dropped from white mature stage to full red stage. After steaming/boiling for 20 minutes, jujube fruit still retained 80% to 90% of its original vitamin C content. After baking for an hour at 375 °F, the jujube fruit still kept 50% of its original vitamin C content. After cold storage at 32 °C for 2 month, Sherwood still kept 90% of its vitamin C content. After cold storage at 32 °C to 35 °C for 2 month, Sherwood still kept 90% of its vitamin C content. Jujube would be a good vitamin C sources for human consumption and 3–5 fresh jujube fruit would meet our daily vitamin C requirement.

Specified Source(s) of Funding: Specialty Crop Block Grant through New Mexico Department of Agriculture

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**Oral Session—Genetics and Germplasm 1**

Moderator: Vanessa Gordon  
USDA-ARS SEA Sugarcane Field Station, Canal Point, FL

1:15–1:30 PM

**Development and Characterization of 12 Polymorphic Microsatellite Loci for *Pityopsis graminifolia* var. *latifolia***

Sarah L. Boggess*  
University of Tennessee, Knoxville, TN

Phillip A. Wadl  
USDA-ARS, Charleston, SC

Denita Hadziabdic  
University of Tennessee, Knoxville, TN

Brian Scheffler  
USDA-ARS, Stoneville, MS

Alan Windham  
University of Tennessee, Nashville, TN

William Klingeman  
University of Tennessee, Knoxville, TN

Robert Trigiano  
University of Tennessee, Knoxville, TN

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

### RNA Expression and Post-transcriptional Editing Analyses of Cucumber Plastids Reveals Genetic Differences Associated with Chilling Tolerance

Vanessa Gordon*  
USDA-ARS SEA Sugarcane Field Station, Canal Point, FL

Jack Staub  
USDA-ARS Forage and Range Research, Logan, UT

D. Kyle Willis  
USDA-ARS, Madison, WI, USA

Phillip Simon  
USDA-ARS Vegetable Crops Research Unit, Madison, WI

Tolerance to chilling injury in cucumber (*Cucumis sativus* L.) is associated with three plastomic single nucleotide polymorphisms (ptSNPs) at bp positions 4,813, 56,561, and 126,349 that are co-inherited. An understanding of the genetic expression of these ptSNPs as a response to chilling is critical for the development of elite germplasm with chilling tolerance. Therefore, a study was designed to elucidate the genotypic and transcriptional effects of these ptSNPs. Sequenom® MassARRAY technology was utilized to characterize heteroplasmy and the degree of post-transcriptional editing in 159 individuals of *P. falcata* and 12 *P. ruthii* individuals were characterized with these markers. The PCR amplicons were separated utilizing the QIAxcel Capillary Electrophoresis System and binned into allelic classes.

Specified Source(s) of Funding: USDA/MOA number 58-6404-7-213

1:30–1:45 PM
from exact reciprocal advanced backcross (ABL: BC₁ₛ₅) and inbred-backcross (IBL: BCₛ₅.) lines grown under greenhouse conditions without chilling. The parents of these populations were ‘Chipper’ (chilling tolerant plastid) and line M29 (chilling susceptible plastid). Additionally, qPCR and RT-qPCR were used to quantify nuclear to plastomic DNA (ptDNA) ratios and ascertain RNA expression changes across the ptSNPs in ‘Chipper’ and M29 after chilling stress (5.5 hours at 4 °C under 270 μmol·s⁻²·m⁻² fluorescent lighting). While ‘Chipper’ was homoplastic and monomorphic for all ptSNPs, M29 was heteroplastic and polymorphic for sites 4,813 and 56,561. Plastidic constitutions were constant in the reciprocal ABL and IBL populations throughout backcross generations. Cucumber line NC-76, which possesses the nuclear chilling gene Ch, was heteroplastic, monomorphic for ptSNP 4,813, and polymorphic for sites 56,561 and 126,349. Although the ptSNPs examined were not edited in ‘Chipper’ mRNA transcripts, ptSNP sites 4,813 and 56,561 were partially and fully edited in M29 transcripts, respectively, restoring the sequence to the predominantly susceptible nucleotide. Data indicate that ptDNA quantity and RNA transcription are similar and consistent in both chilling-response types. Quantitative comparison between ptDNA and a single-copy nuclear marker (CsCYP1: cyclophilin) indicated that the relative ratio of ptDNA to nuclear DNA was approximately 1000:1. This study provides the first known quantification of ptDNA in cucumber, and indicates the absence of ptDNA degradation under these chilling conditions. These results provide increased understanding for more efficient introgression of plastidic chilling tolerance in cucumber.

1:45–2:00 PM

**Genome-wide Differentiation of Various Melon Botanical Groups for Use in GWAS for Fruit Firmness and Construction of a High-resolution Genetic Map**

Padma Nimmakayala*
West Virginia State University, Institute, WV
Yan Tomason
West Virginia State University, Institute, WV
Lakshmi Abburi
West Virginia State University, Institute, WV
Thangasamy Saminathan
West Virginia State University Institute, WV
Venkata Vajja
West Virginia State University, Institute, WV
Girish Panicker
Alcorn State University, Lorman, MS
Umesh Reddy
West Virginia State University Institute, WV

Melon has climacteric and non-climacteric morphotypes that exhibit wide variation for fruit firmness, a very important trait for transportation and shelf life. We generated 13,789 SNP markers using genotyping-by-sequencing and anchored them to various chromosomes to understand genome-wide fixation index between various melon morphotypes and linkage disequilibrium (LD) decay for *inodorus* and *cantalupensis*, the two leading economically important morphotypes. In the current research, we focused on the genome-wide footprints of divergence underlying formation of *inodorus* and *cantalupensis* in comparison with the highly diverse subspecies *agrestis*. Average genome-wide LD decay for the melon genome was noted to be 9.27 Kb. Our study further resolved a strong selective sweep and high LD on chromosomes 11 and 5 indicating importance of these chromosomes in genetic differentiation.

The high-resolution genetic map with 7153 loci constructed in the current study could be used to understand co-linearity with the genome sequence. Genome-wide segregation distortion and recombination rate across various chromosomes is characterized. Various levels of QTLs were identified with high to moderate stringency and linked to fruit pressure using genome-wide association study (GWAS), with the majority of them found to be in agreement with the QTL mapping based on a biparental cross. Gene annotation revealed some of the SNPs are located in β-D-xylosidase and histidine kinase, the genes that were previously characterized for fruit ripening and softening on other crops.

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

2:00–2:15 PM

**Genetic Diversity of Dihydrochalcone Content in *Malus* Germlasm**

Benjamin Gutierrez*
Cornell University & PGRU USDA-ARS, Geneva, NY
Susan Brown
Cornell University, Geneva, NY
Gan-Yuan Zhong
PGRU USDA-ARS, Geneva, NY
C. Thomas Chao
PGRU USDA-ARS, Geneva, NY

The dihydrochalcone phloridzin (phloretin 2'-O-glucoside) is abundant in *Malus* (Mill.) species including the cultivated apple, *M. xdomestica* (Borkh.). Phloridzin has health benefits including anti-cancer, antioxidant, and anti-diabetic properties. Phloridzin has potential in breeding for apple nutritional improvement. While the biosynthetic steps of phloridzin are known, little is known about its genetics or biochemical regulation. This research explores the genetic diversity of phloridzin content in *Malus* germplasm. Phloridzin content was measured using High Performance Liquid Chromatography (HPLC) in leaf samples for three years in 345 accessions, representing 29 species and 16 interspecific hybrids from the USDA *Malus* germplasm collection. Leaf phloridzin content ranged from 17.3 to 113.7 mg/g and genotype accounted for 62% of the observed variation. Between-year correlations were high (r = 0.70), indicating seasonal stability. In addition to phloridzin, the dihydrochalcones sieboldin (3-hydroxyphloretin 4'-O-glucoside) and trilobatin (phloretin 4'-O-glucoside) were detected in certain

An asterisk (*) following a name indicates the presenting author.
accessions. These compounds distinguish some *Malus* species, with sieboldin or trilobatin replacing phloridzin in some accessions. Within the collection sampled, 274 accessions (79%) contained phloridzin as the primary dihydrochalcone, 29 (8%) contained sieboldin and trilobatin, and 44 (13%) contained phloridzin, sieboldin, and trilobatin. Extensive qualitative and quantitative variation in dihydrochalcone content was identified in this germplasm survey.

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

2:15–2:30 PM

**Molecular Diversity Among Bitter Melon (Momordica charantia L.) Genotypes Using SSRs and SNPs**

Padma Nimmakayala*
West Virginia State University, Institute, WV

Lakshmi Abburi
West Virginia State University, Institute, WV

Venkata Vajja
West Virginia State University, Institute, WV

Umesh Reddy
West Virginia State University, Institute, WV

Bitter melon (syn. bitter gourd, balsam pear, snap melon; *Momordica charantia* L.; Family Cucurbitaceae; 2n = 22) is grown traditionally in the tropical and subtropical areas of Asia, the Amazon, east Africa, and the Caribbean as food vegetable and medicine. Bitter melon is the most extensively used food crop for prevention and cure of cancer and diabetes. The cultivation and consumption of the fruit and fruit extracts of bitter melon are becoming increasingly popular now in the United States. Presently, it is grown in at least eight states (Alabama, Connecticut, Florida, Hawaii, Louisiana, Pennsylvania, Texas, and Kentucky) and also in Puerto Rico and the Virgin Islands. In the recent past, molecular markers including random amplified polymorphic DNA (RAPD), inter-simple sequence repeat (ISSR), and amplified fragment length polymorphism (AFLP) markers have been used to evaluate genetic diversity in bitter melon. However, no microsatellite or SSR (simple sequence repeat markers) has been developed in this crop. To fill this gap, we recently sequenced cDNA made from the RNA of fruit tissue and obtained 193,596 reads using Illumina HiSeq and identified 1203 sequences containing di and tri microsatellite motifs. In addition to this, we have collected 96 varieties of diverse pedigree and geographical origin (India, China, Japan, Thailand, Taiwan, and Hong Kong) and identified SNPs using GBS (Genotyping by sequencing) technology. Observations recorded on six fruit characters including color (white vs. green), shape (long vs. round), surface (spiny vs. non-spiny), size (large vs. small) and bitterness (bitter vs. less-bitter) revealed contrasting variation among the accessions.

An asterisk (*) following a name indicates the presenting author.
Genetic Diversity Assessment of Garlic Clones with SSR Markers

Ahmet Ipek
Uludag University, Bursa, Turkey
Meryem Ipek*
Uludag University, Bursa, Turkey
Philipp Simon
USDA, Madison, WI

Garlic (Allium sativum L.) as a clonally propagated crop has notable genetic diversity among the genotypes and cultivars growing worldwide. Simple sequence repeats (SSRs) are very valuable molecular markers for both genotyping and genetic mapping studies in plants. For the garlic genome, however, a limited number of SSR markers have been developed. In this study, 26 polymorphic SSR markers were developed from the expressed regions of the garlic genome. The genetic diversity among the 31 garlic genotypes from different parts of the world was investigated by using these novel SSR markers. A total of 130 polymorphic markers were detected with a range of 2 to 13 and average of 5 alleles per SSR locus. Seven SSR loci had more than one locus in garlic genome, which is not unexpected for a crop with very large genome size. While the genetic similarity was as low as 40% among the individuals, 12 garlic clones could not be distinguished from each other with 130 polymorphic SSR markers, which are most likely duplicate genotypes in the germplasm collections. Grouping of garlic clones in UPGMA dendrogram was highly similar to previously reported amplified fragment length polymorphism (AFLP), randomly amplified polymorphic DNA (RAPD) and isozymes molecular marker analyses of same garlic genotypes. This result indicates immediate utility of newly developed SSR markers in garlic genetic studies.

Specified Source(s) of Funding: The Commission of Scientific Research Projects of Uludag University

Inheritance of Resistance to Peach Root-knot Nematode (Meloidogyne floridensis) in Interspecific Populations of Peach

Mary Ann D. Maquilan*
University of Florida, Gainesville, FL
José X. Chaparro
University of Florida, Gainesville, FL
Mercy Olmstead
University of Florida, Gainesville, FL
Donald W. Dickson
University of Florida, Gainesville, FL

We examined several F₁ and BC₁F₁ populations that were generated from interspecific crosses between Prunus kansuensis Rehder (Kansu peach) and Prunus persica (L.) Batsch (peach) for segregation of resistance to the peach root-knot nematode (RKN), Meloidogyne floridensis (MF). The segregation analyses were based on fourteen different populations with P. kansuensis as the common male parent and each population comprised of forty individual genotypes. Eight F₁ populations were generated from self-fertilization of ‘Okinawa’ peach or ‘Flordaguard’ peach x P. kansuensis hybrids. Six BC₁F₁ populations were from ‘Okinawa’ x P. kansuensis or ‘Flordaguard’ x P. kansuensis hybrids backcrossed to ‘UFSharp’ peach, which has a known susceptibility to RKN, or to ‘Flordaguard’ peach, which expresses a certain degree of RKN resistance. Response to MF was evaluated by inoculating with a single MF population isolated from peach in

An asterisk (*) following a name indicates the presenting author.
QTL Mapping for Phytochemical Compounds in Peach [Prunus persica (L.) Batsch]

Asma Abdelghafar*
Clemson University, Clemson, SC
Ksenija Gasic
Clemson University, Clemson, SC
Gregory Reighard
Clemson University, Clemson, SC

Genetic control and location of QTLs associated with phytochemical compounds in peach were evaluated using bi-parental mapping and genome wide association study (GWAS). The bi-parental mapping was conducted in an F2 population (ZC2) derived from cross between two peach cultivars ‘Zin Dai’ x ‘Crimson Lady’. GWAS was performed on an association panel of 105 peach and nectarine accessions from Clemson University’s peach germplasm, representing modern peach cultivars available and/or produced for the U.S. market. Antioxidant capacity and phenolic compound accumulation (total phenolics, flavonoids and anthocyanin) were evaluated for two years on all material. The ZC2 progeny were genotyped using IPSC 9K peach SNP array v1., and the association panel was genotyped using genotyping-by-sequencing (GBS). The genetic linkage map was constructed with 908 SNP markers distributed among eight linkage groups, with 347 SNPs uniquely mapped. The map covers a genetic distance of ~336 cM, with an average marker density of 1.07 cM/ marker. Total of 10 QTLs associated with phytochemical (PC) traits were identified on 5 linkage groups (LGs). Two major QTLs were observed on two linkage groups, LG 6 and 8. Major QTL on LG6, qPC.ZC-6.1 was associated with all phytochemical compounds measured, while qPC.ZC-8.1 exhibited association only with total phenolics and anthocyanin content. GWAS was performed on a dataset of 35,198 SNPs and all phytochemical compounds using the General Linear Model (GLM), and accounted for the population structure within the analyzed germplasm. Significant association (P < 0.05) was observed for 94 SNPs covering the entire genome. Majority of SNPs (90) were associated with anthocyanin accumulation and spread across all LGs, while 4 SNPs were associated with both antioxidant capacity and flavonoid content. Although none of the SNPs associated with phytochemical content detected via GWAS overlapped with the single QTL identified using the bi-parental population, many were found in flanking regions. Furthermore, a single SNP associated with anthocyanin on LG3 flanked the major blush QTL PprMYB10 detected previously in the same progeny. Feasibility of enabling marker-assisted breeding for phytochemical composition will be discussed.

**Specified Source(s) of Funding:** USDA-AMS-SCBGP 12-25-B-1695

8:45–9:00 AM

**Molecular Characterization of Aphid Resistance in Black Raspberry Germplasm**

Jill Bushakra*
USDA-ARS, NCGR, Corvallis, OR
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USDA-ARS, NCGR, Corvallis, OR
Kelly J. Vining
Oregon State University, Corvallis, OR
Michael Dossett
B.C. Blueberry Council (in partnership with Agriculture and Agri-Food Canada), Pacific Agri-Food Research Centre, Agassiz, BC, Canada
Jana C. Lee
USDA-ARS, HCRU, Corvallis, OR
Jungmin Lee
USDA-ARS, HCRU, Parma, ID
Chad E. Finn
USDA-ARS, HCRU, Corvallis, OR
Nahla Bassil
USDA-ARS, NCGR, Corvallis, OR

Black raspberry is a minor but lucrative crop with most of the U.S. acreage in grown in Oregon. One of the challenges for black raspberry growers is the rapid decline of plantings resulting from aphid-borne virus infection. The North American large raspberry aphid is a vector of Black raspberry necrosis virus (BRNV) and other viruses in the Raspberry mosaic virus complex, to which all available cultivars are susceptible. BRNV spreads rapidly in the field resulting in plantings that decline in as few as two or three growing seasons. Aphid resistance was discovered in each of three separate wild black raspberry populations collected from Simcoe, Ontario, Canada (ON), Gardiner, Maine, USA (ME), and Bath, Michigan, (MI). Three full-sib black raspberry populations, designated ORUS 4305 (ON), ORUS 4304 (ME), and ORUS 4812 (MI), were used to study the inheritance of the aphid resistance from the three sources. We have successfully mapped the locus for the ON source of resistance, designated A4g, on Rubus Linkage Group 6. Association analysis suggests that black raspberry genome sequence Scaffolds 99, 525 and 684 are important for determining aphid resistance in population ORUS 4305. We have identified simple sequence repeat (SSR) loci throughout these three scaffolds and have screened the loci in a subset of each population. To date, ten SSR loci on Scaffold 99 (S99) that segregate with aphid resistance have been identified, while screening of the loci for Scaffolds 525 and 684 is in progress. Preliminary results suggest that all three

An asterisk (*) following a name indicates the presenting author.
resistance loci are linked and strongly associated with S99 and that each represents a unique locus. All markers will be validated in populations with mixed sources of resistance.

**Specified Source(s) of Funding:** USDA-ARS CRIS 5358-21000-038-00D, 5358-21000-041-00D, 5358-21000-037-00D

9:00–9:15 AM

**Detecting Local Adaptation for Rhizosphere Acidification in a Wild Deciduous Azalea Species**

Alexander Susko*
University of Minnesota, St. Paul, MN

Jim Bradeen
University of Minnesota, St Paul, MN

Timothy Rinehart
USDA-ARS, SHL, Poplarville, MS

Stan Hokanson
University of Minnesota, St Paul, MN

Measures of genetic differentiation provide useful benchmarks by which to compare quantitative trait differentiation in woody species. These analyses, typically known as $Q_{st}$-$F_{st}$ comparisons, can infer whether a quantitative trait is locally adapted in a population. Such experiments produce not only ecological insights, but useful breeding directions and identify new germplasm sources for quantitative traits of interest. We set out to determine the genetic differentiation in a wide-ranging deciduous azalea *Rhododendron viscosum* (L.) Torr, a species of breeding interest due to its late bloom and general abiotic stress tolerance. We identified seven broad subpopulations across the southern United States from Arkansas to Florida encompassing a variety of environments. We developed 14 SSR loci from a sequenced *R. viscosum* bud transcriptome for estimations of subpopulation genetic differentiation based on $F_{st}$ and $R_{st}$ statistics. We compared this to the quantitative trait differentiation of rhizosphere acidification, a candidate trait for pH adaptability in deciduous azalea. To determine if rhizosphere acidification was locally adapted, we estimated the trait $Q_{st}$ value, or ratio of trait additive variance among versus within subpopulations, from the progeny of 19 maternal half-sib families. Though rhizosphere acidification was not locally adapted, we consider this research to be a blueprint for investigating novel, quantitative traits in uncharacterized woody species.

**Specified Source(s) of Funding:** Southern California Plumeria Society

9:30–9:45 AM

**Evidence of Interspecific Hybridization or Incomplete Lineage Sorting in River Cane (Arundinaria gigantea)**

Alex Rajewski*
University of California, Riverside, Riverside, CA

Cecilia McGregor
University of Georgia, Athens, GA

Donglin Zhang
University of Georgia, Athens, GA

Hazel Wetzstein
Purdue University, West Lafayette, IN

River cane (*Arundinaria gigantea*) is an ecologically valuable species of temperate woody bamboo endemic only to the southeastern United States. This species typically grows in dense, monotypic stands along river banks, and clonal growth within stands is expected to be high. Since European settlement of North America, River cane has seen significant population decline, and there is currently growing interest in restoration of River cane populations in their natural range. In order to better inform both field collection and restoration efforts, it is important to understand the genotypic and clonal make up of existing stands. In this study, three natural populations of River cane were investigated for genotypic diversity. Thirty-five SSR

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

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Physiological disorder called intumescence has been observed in tomato seedlings of sensitive cultivars grown under LED light, presumably due to the lack of UV-B light. A previous study showed that phytochrome is involved in regulating intumescence and high phytochrome photostationary state (Pfr/Ptotal, such as 0.9 for red light) under UV-B deficit light induces intumescence in tomato. In our previous research the intumescence symptoms were mitigated by end-of-day (EOD) far red (FR) lighting (Pfr/Ptotal = 0.1). However, seedlings grown with EOD FR light become extensively stretched. Monochromatic blue (B) light has relatively low Pfr/Ptotal of 0.5. Further, B light may increase stomatal conductance through the action of blue light receptors, and thereby potentially mitigates the turgor in cells that may induce the problematic hypertrophy when applied during the night. Therefore, this study focused on application of B light as a possible means to mitigate intumescences. B light was applied for ‘Beaufort’ tomato seedlings in two ways (with the same B light dose of 0.17 mol·m⁻²·d⁻¹): 1) EOD light (20 μmol·m⁻²·s⁻¹ for 2.5 hours, followed by 3.5-hour darkness and 18-hour photoperiod) and 2) overnight lighting (8 μmol·m⁻²·s⁻¹ for 6 hours, followed by 18-hour photoperiod). Light during the photoperiod was provided by B and R LEDs at 200 ± 5 μmol·m⁻²·s⁻¹ (10% B, Pfr/Ptotal = 0.9). In addition, no lighting (6 hours, followed by 18-hour photoperiod) or overnight R or FR lighting (8 μmol·m⁻²·s⁻¹, Pfr/Ptotal = 0.9 or 0.1, respectively) was examined for comparison. We repeated the experiment twice. For both repetitions, consistently, the control or R light treatment developed severe intumescence injury and FR treatment mitigated the symptom. For example, leaf area exhibiting intumescence injury in second true leaf was 55% to 63% smaller and fresh weight was 28% to 78% greater under FR than under the control or R light treatment. In contrast, B light effect was somewhat inconsistent. The first experiment showed significant but mild mitigation of intumescence under both B light treatments, resulting in 31% to 47% greater fresh weight than under the control or R light treatment. However, intumescence inhibitory effects were not significant when the experiment was repeated. These results have shown that monochromatic blue light has no or little effect on intumescence compared with FR light.

**Oral Session—Growth Chambers and Controlled Environments 1**

Moderator: Geoffrey Weaver  
University of Georgia, Athens, GA

8:00–8:15 AM

**Effects of Monochromatic Blue Light on Intumescence Injury for Tomato Seedlings Grown Under LEDs**

Tomohiro Jishi*  
The University of Arizona, Tucson, AZ

Chieri Kubota  
The University of Arizona, Tucson, AZ

Tomomi Eguchi  
The University of Arizona, Tucson, AZ

Physiological disorder called intumescence has been observed in tomato seedlings of sensitive cultivars grown under LED light, presumably due to the lack of UV-B light. A previous study showed that phytochrome is involved in regulating intumescence and high phytochrome photostationary state (Pfr/Ptotal, such as 0.9 for red light) under UV-B deficit light induces intumescence in tomato. In our previous research the intumescence symptoms were mitigated by end-of-day (EOD) far red (FR) lighting (Pfr/Ptotal = 0.1). However, seedlings grown with EOD FR light become extensively stretched. Monochromatic blue (B) light has relatively low Pfr/Ptotal of 0.5. Further, B light may increase stomatal conductance through the action of blue light receptors, and thereby potentially mitigates the turgor in cells that may induce the problematic hypertrophy when applied during the night. Therefore, this study focused on application of B light as a possible means to mitigate intumescences. B light was applied for ‘Beaufort’ tomato seedlings in two ways (with the same B light dose of 0.17 mol·m⁻²·d⁻¹): 1) EOD light (20 μmol·m⁻²·s⁻¹ for 2.5 hours, followed by 3.5-hour darkness and 18-hour photoperiod) and 2) overnight lighting (8 μmol·m⁻²·s⁻¹ for 6 hours, followed by 18-hour photoperiod). Light during the photoperiod was provided by B and R LEDs at 200 ± 5 μmol·m⁻²·s⁻¹ (10% B, Pfr/Ptotal = 0.9). In addition, no lighting (6 hours, followed by 18-hour photoperiod) or overnight R or FR lighting (8 μmol·m⁻²·s⁻¹, Pfr/Ptotal = 0.9 or 0.1, respectively) was examined for comparison. We repeated the experiment twice. For both repetitions, consistently, the control or R light treatment developed severe intumescence injury and FR treatment mitigated the symptom. For example, leaf area exhibiting intumescence injury in second true leaf was 55% to 63% smaller and fresh weight was 28% to 78% greater under FR than under the control or R light treatment. In contrast, B light effect was somewhat inconsistent. The first experiment showed significant but mild mitigation of intumescence under both B light treatments, resulting in 31% to 47% greater fresh weight than under the control or R light treatment. However, intumescence inhibitory effects were not significant when the experiment was repeated. These results have shown that monochromatic blue light has no or little effect on intumescence compared with FR light.

8:15–8:30 AM

**Pulse Width Modulation Control of LEDs Can Maintain Targeted Light Levels**

David Gianino*  
University of Georgia, Athens, GA

Marc van Iersel  
University of Georgia, Athens, GA

LEDs are becoming more popular for use in indoor growing operations and supplemental lighting in greenhouses to promote growth. The capital cost of LED lights is high and may slow adoption of LED lights. The light output of LEDs can be adjusted by manipulating the duty cycle (duration of power “on” compared to “off” during a given, very short cycle). That may result in energy savings, improving the economic feasibility of LEDs. Our goal was to see if the light output from LED light bars can be adjusted automatically to maintain the photosynthetic photon flux (PPF) at or above a specific target level in the presence of variable sunlight. Four sensors measured the PPF levels of sunlight and the PPF underneath three LED bars. Using a datalogger, the LED light bars were controlled in three ways: 1) LED bar on at full power for 14 hours/day; 2) LED bar on at full power when the sunlight was below a specified PPF level (for 14 hours/day); and 3) an LED light bar controlled with a pulse width modulation (PWM) board to adjust the duty cycle of that light bar, so that the combined amount of PPF below the light bar (from sun plus LEDs) did not drop below a specific PPF target level. The target PPF level was changed daily to 50, 100, 150, 200, or 250 μmol·m⁻²·s⁻¹. The PWM-controlled LED bar successfully maintained target PPF levels in response to shading or cloud cover. Compared to the control treatment, PWM control of the LEDs based on PPF reduced power use by 20 to 92%, depending on daily light integral (DLI) and target.
With a target PPF of 250 μmol·m⁻²·s⁻¹, PWM control of the LEDs reduced power use by 20% on a day with a DLI of 2.5 mol·m⁻²·d⁻¹ and 53% when the DLI was 8.5 mol·m⁻²·d⁻¹. With a target PPF of 50 μmol·m⁻²·s⁻¹, power use was reduced by 90% to 92%. Energy savings were less when the LEDs were simply turned on or off based on PPF (0% to 60%, depending on DLI and target PPF). Controlling LED lights using PWM can assure that the lights are only on when needed and at the minimum power needed to provide adequate. The potential energy savings of using PWM control of LED lights to maintain a specific minimum target PPF will lower the operating costs of using LEDs and make them more economical.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation, American Floral Endowment

8:30–8:45 AM

**Maintaining Minimum Light Levels with LEDs Results in More Energy-efficient Growth Stimulation of Begonia**

Marc van Iersel*
University of Georgia, Athens, GA

Sue K. Dove
University of Georgia, Athens, GA

Supplemental lighting is often needed for the production of high quality bedding plants for spring sales. However, the energy costs associated with lighting can be high. To reduce the electricity costs, we developed a system that automatically controls the light output from LED grow lights to supplement the available sunlight as needed. The system provides just enough light from LEDs to assure that the total amount of light, from sunlight plus LEDs, never drops below a user-adjustable threshold. To test crop responses to different lighting treatments, we grew begonia (*Begonia x tuberhybrida pendula*) ‘Illimination Apricot’ with five different lighting treatments: sunlight only, 14 hours/day of supplemental light from a red and blue LED light bar, and three treatments where the photosynthetic photon flux (PPF) was maintained at a minimum level of 50, 125, or 200 μmol·m⁻²·s⁻¹ for 14 hours/day. Compared to 14 hours/day of constant supplemental lighting, the treatments with minimum PPF levels of 50, 125, and 200 μmol·m⁻²·s⁻¹ reduced electricity used for lighting by 93%, 76%, and 62%, respectively. Shoot dry weight was increased by 30%, 98%, 132%, and 166% compared to plants not receiving supplemental light in the 50, 125, or 200 μmol·m⁻²·s⁻¹ and 14 hours/day treatments, respectively. Providing constant supplemental light for 14 hours/day resulted in the least efficient growth stimulation, as measured by the increase in growth divided by the power used by LEDs. These results indicate that adjusting the amount of supplemental light based on how much sunlight is present can reduce electricity costs, while achieving the growth-promoting benefits of supplemental lighting in a more cost- and energy-efficient way.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation, American Floral Endowment

8:45–9:00 AM

**Physiological Responses of Baby Leaf Lettuce to Different Blue and Red Photon Flux Ratios Using LED As Sole-source Lighting**

Hans Spalholz*
North Carolina State University, Raleigh, NC

Ricardo Hernández
North Carolina State University, Raleigh, NC

Light emitting diodes (LEDs) are increasingly used in controlled environment production as supplemental and sole-source lighting. As the effect of light on specialty crops is specific to each species, it is necessary to understand the impact of light on morphological and physiological traits of specific crops. Indoor-crop production via containerized growing (aka vertical farms) lacks standardized growing protocols including lighting requirements to optimize plant growth and reduce energy usage. Lettuce (*Lactuca sativa*) cv. Red Oakleaf was grown until the commercial harvest stage (average 70 g fresh mass) under 22 °C average temperature, 30% to 50% relative humidity, ambient CO₂, 200 μmol·m⁻²·s⁻¹ photon flux and 18-h photoperiod (daily light integral: 13 mol·m⁻²·d⁻¹). Light treatments consisted of different percentages of blue (B) and red (R) photon flux ratios of 0B:100R, 10B:90R, 20B:80R, 50B:50R, 80B:20R, and 100B:0R. Cool-white fluorescence was used as the control treatment. Physiological plant responses such as fresh mass, dry mass, shoot and leaf length, leaf count, leaf area, anthocyanin concentration, chlorophyll concentration, visual quality, net photosynthetic rate, stomatal conductance, and nutrient content were collected and compared between the lighting treatments. The optimal light spectrum will be evaluated in terms of plant growth rate, plant morphology, and plant quality. In addition, the results will provide the estimated growing efficacy of each spectrum in terms of grams of produce per kWh of energy. Results will help determine which ratios of blue and red photon flux are most appropriate for commercial producers using LEDs in indoor growing systems.

9:00–9:15 AM

**Continuous Chlorophyll Fluorescence Monitoring of Greenhouse-grown Lettuce** (*Lactuca sativa L.*).

Geoffrey Weaver*
University of Georgia, Athens, GA

Marc van Iersel
University of Georgia, Athens, GA

Chlorophyll fluorescence measurements are an effective means of rapidly assessing the performance of photosystem II (PSII). Long-term chlorophyll fluorescence monitoring can provide useful information about photosynthetic efficiency under changing environmental conditions. Chlorophyll fluorescence
of a greenhouse-grown crop of romaine type lettuce (Lactuca sativa L. ‘Green Towers’) consisting of 15 plants was continuously monitored in situ for 5 weeks beginning at 2 weeks after germination. Measurements were taken on a single leaf after the dark-adapted quantum efficiency of PSII ($F_{m}/F_{n}$) was determined. Every 2 d, the fluorometer was moved to a leaf on a different plant. The quantum yield of PSII ($\Phi_{PSII}$) and photosynthetic photon flux density (PPFD) were measured every 15 min. The electron transport rate through PSII (ETR) was estimated from $\Phi_{PSII}$ and PPFD. The daily light integral (DLI) was calculated from the PPFD measurements and ranged from 2.3 to 28.5 mol·m$^{-2}$·d$^{-1}$ (13.8 ± 6.3 mol·m$^{-2}$·d$^{-1}$). The integral of ETR over a day, or daily photochemical integral (DPI, mol·m$^{-2}$·d$^{-1}$), was calculated for each day. As DLI increased, DPI increased asymptotically from 0.75 to 3.39 mol·m$^{-2}$·d$^{-1}$ ($R^2 = 0.84, P < 0.001$), with little or no increase at DLIs greater than 15.5 mol·m$^{-2}$·d$^{-1}$. Over all measurement days, ETR increased asymptotically to 126 μmol·m$^{-2}$·s$^{-1}$ as PPFD increased, with little or no increase at PPFDs greater than 800 μmol·m$^{-2}$·s$^{-1}$ ($R^2 = 0.91, P < 0.001$). A corresponding decrease in $\Phi_{PSII}$ with increasing PPFD to a minimum of 0.13 was also observed ($R^2 = 0.91, P < 0.001$). Throughout the study $F_{m}/F_{n}$ remained relatively constant at 0.85 ± 0.01, indicating that the maximum efficiency of PSII did not change with plant age. These results demonstrate that chlorophyll fluorescence monitoring could be effectively used to develop crop-specific lighting recommendations.

9:15–9:30 AM

**Blue, Red, and Far-red Radiation Interact to Influence Growth, Morphology, and Pigmentation of Lettuce and Basil**

Qingwu Meng*  
Michigan State University, East Lansing, MI

Erik Runkle  
Michigan State University, East Lansing, MI

Horticultural lighting has primarily focused on photosynthetically active radiation, especially blue (B, 400 to 500 nm) and red (R, 600–700 nm), and its effects on plant growth. However, far-red (FR, 700–800 nm) radiation regulates numerous pathways crucial to photomorphogenesis, thus meriting consideration in sole-source plant lighting applications. We investigated how interactions among B (peak = 450 nm), R (peak = 660 nm), and FR (peak = 730 nm) radiation from light-emitting diodes influenced growth of green butterhead lettuce (Lactuca sativa) ‘Rex’, red oakleaf lettuce ‘Cherokee’, and basil (Ocimum basilicum) ‘Genovese’. Seedlings were grown in a growth chamber licium-‘Rex’, red oakleaf lettuce ‘Cherokee’, and basil (600–700 nm) to far-red (700–800 nm) ratio during night interruption on vegetative growth in Cymbidium cultivars to reduce production period and improve plant quality. We grew three-month-old Cymbidium cultivars, ‘Yangguifei’, ‘Wine Showe’, ‘Polaire’, and ‘Happy Day’ in a greenhouse which is located in Gongju, Chungnam Province (36°22’1.9”N, 127°04’32.4”E) under natural photoperiod and temperature. Light intensity of all NI lighting treatments was fixed at 129 ± 5 μmol·m$^{-2}$·s$^{-1}$. Light with R:FR ratio (0.8, 1.2, 1.5, and 2.2) or red 100% (R) were provided by using red LEDs (peak = 660 nm) mixed with far-red LEDs (peak = 730 nm). A pseudobulb diameter in all cultivars grown under NI was higher than those grown under non-NI treatment. The pseudobulb diameter was the greatest when the plants were grown under R in ‘Yangguifei’ and ‘Wine Showe’. However, there were no differences among NI treatments in ‘Happy Day’ and ‘Polaire’. Overall, leaf length of ‘Yangguifei’, ‘Polaire’, and ‘Happy Day’ grown under NI treatments increased as R:FR ratio decreased. However, the leaf length of ‘Wine Showe’ was the greatest under R:FR 1.5, which is similar to R:FR ratio found in natural solar light. We conclude that R:FR ratios in high intensity NI lighting could control vegetative growth of Cymbidium, although responses

An asterisk (*) following a name indicates the presenting author.
to R:FR ratio varied depending on cultivars. Therefore, further
detailed studies are needed to characterize the effects of R/FR
ratio during NI lighting in *Cymbidium* cultivation.

**Specified Source(s) of Funding:** Korea Institute of Planning
and Evaluation for Technology in Food, Agriculture, Forestry
and Fisheries

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**Oral Session—Postharvest 1**

Moderator: Mahnaz Kargar
Auburn University, Auburn, AL

8:00–8:15 AM

**Effect of Maturity and Optimized Solvent Extraction Conditions for Total Phenolic Content of Selected Genomically Diverse Banana Cultivated in Southeastern United States**

Mahnaz Kargar*
Auburn University, Auburn, AL

Floyd Woods
Auburn University, Auburn, AL

Kalidas Shetty
North Dakota State University, Fargo

Dipayan Sarkar
North Dakota State University, Fargo

Marisa Wall
USDA-ARS, Hilo, HI

Suzanne Sanxter
U.S. Pacific Basin Agricultural Research Center, Hilo

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Auburn University, Auburn, USA

J. Raymond Kessler
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Esendugue Greg Fonsah
University of Georgia–Tifton Campus

Curtis Jolly
Auburn University, Auburn, AL

Nicholas Larsen
University of Florida, Belle Glade, FL

Diabetes mellitus (DM) is a major cause of heart disease and stroke and the seventh leading cause of mortality in the United States. Natural plant based bioactive compounds offer appealing therapeutic strategy in ameliorating type 2 diabetes. Banana (*Musa* spp.) is a rich source of phytonutrients and antioxidants in particular phenolic compounds providing health benefits to consumers. Extraction efficiency of phenolic compounds may vary considerably dependent on solvent. Critical to future applications in food, nutraceutical and pharmaceutical industries requires optimization of extraction conditions for phenolic compounds. Stage of maturity may have a profound influence on phytonutrient content and bioactive compound extractability. There is a vital need for identification, determination, and selection of phenolic enriched banana cultivars adaptable to the southeastern United States. Therefore, collaborative research efforts between Alabama, Florida, Georgia, Hawaii, and North Dakota, were initiated to accomplish the stated objectives in order to establish a local niche market. Banana cultivars varying in genotype ‘FHIA’ (AAAB), ‘Hua Mua’ (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% RH (mature green, transition, ripe, and overripe). Three extraction solvents (50 methanol: water; 50 acetone: water; and 1 acetic acid : 50 acetone : 49 water) were utilized to determine optimal extractability and recovery of total phenolic content in banana fruit pulp tissues. Extracts were analyzed for total phenolic content as determined by Folin-Ciocalteau method. Results indicate that solvent effectiveness with regard to extractability of total phenolic content varied considerably. There were significant cultivar by maturity stage by solvent interactions ($P \leq 0.05$). Acetic acid–acetone–water (1:50:49), provided the most efficient solvent with respect to cultivar and maturity stage. Moderate and lowest extractability of total phenolic content was observed for acetone-water (50:50) and methanol–water, (50:50), respectively. ‘Hua Mua’ (AAB), ‘Kandarian’ (ABB), ‘Pisang Raja’ (AAB), and ‘Williams’ (AAA) were observed highest in total phenolic content at ripe stage and in conjunction with acetic acid–acetone-water (1:50:49). ‘Pisang Raja’ (AAB), and ‘FHIA’ (AAAB) genotypes exhibited highest extractable total phenolic content. Acetic acid–acetone–water (1:50:49), provided the most efficient extraction solvent for recovery of phenolics from banana fruit tissue. Results suggest that extracts from acetic acid–acetone–water may serve as a potential source of natural antioxidant for food, nutraceutical and pharmaceutical applications. Continuing research efforts will characterize the relationship between phenolic content and antioxidant activity and capacity in extracts of banana fruit pulp tissue.

8:15–8:30 AM

**Effect of Maturity on Carotenoid Profile of Selected Genomically Diverse Banana Cultivated in the Southeastern United States**

Mahnaz Kargar*
Auburn University, Auburn, AL

Marisa Wall
USDA-ARS, Hilo, HI

Suzanne Sanxter
U.S. Pacific Basin Agricultural Research Center, Hilo

Sandra Silva
U.S. Pacific Basin Agricultural Research Center, Hilo

Floyd Woods
Auburn University, Auburn, AL

Esendugue Greg Fonsah
University of Georgia–Tifton Campus

Curtis Jolly
Auburn University, Auburn, AL

Nicholas Larsen
University of Florida, Belle Glade, FL

Diabetes mellitus (DM) is a major cause of heart disease and stroke and the seventh leading cause of mortality in the United States. Natural plant based bioactive compounds offer appealing therapeutic strategy in ameliorating type 2 diabetes. Banana (*Musa* spp.) is a rich source of phytonutrients and antioxidants in particular phenolic compounds providing health benefits to consumers. Extraction efficiency of phenolic compounds may vary considerably dependent on solvent. Critical to future applications in food, nutraceutical and pharmaceutical industries requires optimization of extraction conditions for phenolic compounds. Stage of maturity may have a profound influence on phytonutrient content and bioactive compound extractability. There is a vital need for identification, determination, and selection of phenolic enriched banana cultivars adaptable to the southeastern United States. Therefore, collaborative research efforts between Alabama, Florida, Georgia, Hawaii, and North Dakota, were initiated to accomplish the stated objectives in order to establish a local niche market. Banana cultivars varying in genotype ‘FHIA’ (AAAB), ‘Hua Mua’ (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% RH (mature green, transition, ripe, and overripe). Three extraction solvents (50 methanol: water; 50 acetone: water; and 1 acetic acid : 50 acetone : 49 water) were utilized to determine optimal extractability and recovery of total phenolic content in banana fruit pulp tissues. Extracts were analyzed for total phenolic content as determined by Folin-Ciocalteau method. Results indicate that solvent effectiveness with regard to extractability of total phenolic content varied considerably. There were significant cultivar by maturity stage by solvent interactions ($P \leq 0.05$). Acetic acid–acetone–water (1:50:49), provided the most efficient solvent with respect to cultivar and maturity stage. Moderate and lowest extractability of total phenolic content was observed for acetone-water (50:50) and methanol–water, (50:50), respectively. ‘Hua Mua’ (AAB), ‘Kandarian’ (ABB), ‘Pisang Raja’ (AAB), and ‘Williams’ (AAA) were observed highest in total phenolic content at ripe stage and in conjunction with acetic acid–acetone-water (1:50:49). ‘Pisang Raja’ (AAB), and ‘FHIA’ (AAAB) genotypes exhibited highest extractable total phenolic content. Acetic acid–acetone–water (1:50:49), provided the most efficient extraction solvent for recovery of phenolics from banana fruit tissue. Results suggest that extracts from acetic acid–acetone–water may serve as a potential source of natural antioxidant for food, nutraceutical and pharmaceutical applications. Continuing research efforts will characterize the relationship between phenolic content and antioxidant activity and capacity in extracts of banana fruit pulp tissue.
Mean α-carotene ranged from 0 to 1316 μg/100 g FW for β-carotene at MG stage and 172 μg/100 g FW at the OR stage. ß-carotene and lutein had a range of 0 to 172 μg/100 g FW for both cultivars and maturity stages. Results indicate, α- and ß-carotene and lutein were the prominent carotenoids detected. Maturity stage by cultivar interaction was significant at P<0.05 for subsequent carotenoid retention and bioavailability studies.

Stage of maturity may have a profound influence on bioactive compounds in banana fruit. This study therefore, determined the effect of maturity on carotenoid composition in diverse genomic short-cycle banana cultivars. Banana (Musa spp.) contains several bioactive compounds that have positive effects on human health. Many of these compounds possess antioxidant properties that protect against non-communicable chronic disease associated with oxidative stress. Observational studies indicate an inverse association of α- and ß-carotene and reduced risk of type 2 diabetes. Collaborative research effort between Alabama, Florida, Georgia, Hawaii, and North Dakota investigators was initiated to identify underutilized carotenoid enriched banana cultivars adaptable to Southeastern United States and destined for development of local niche market. A critical step in hypothesis development concerning dietary carotenoid intake and type 2 diabetes is the determination of carotenoid composition of these underutilized banana cultivars. Stage of maturity may have a profound influence on bioactive compounds in banana fruit. This study therefore, determined the effect of maturity on carotenoid composition in diverse genomic short-cycle banana cultivated in southeastern United States, as established by high performance liquid chromatography (HPLC) analysis. Six cultivars varying in genotype ‘FHIA’ (AAAB), ‘Hua Mua’ (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 (mature green MG, transition TR, ripe R, and overripe OR) in order to establish postharvest ripening behavior for subsequent carotenoid retention and bioavailability studies. Results indicate, α- and ß-carotene and lutein were the prominent carotenoids detected. Maturity stage by cultivar interaction was significant at P<0.05 for α-carotene, β-carotene, and lutein concentrations. In contrast, no difference was observed among cultivar or maturity in regard to β-cryptoxanthin and lycopene. Mean α-carotene ranged from 0 to 1316 μg/100 g FW, β-carotene 0 to 1297 μg/100 g FW and lutein 0 to 172 μg/100 g FW dependent on cultivar and maturity stage. Highest carotenoid concentration with respect to lutein was observed in FHIA (AAAB) with an average of 172 μg/100 g FW at the OR stage and Hua Mua (AAB) with an average of 1316 μg/100 g FW for α-carotene and 1297 μg/100 g FW for β-carotene at MG stage respectively. These findings indicate carotenoid composition of diverse genomic short-cycle banana cultivated in southeastern United States, vary considerably dependent on cultivar and maturity. Results of this study will assist banana producers in the selection of cultivars adaptable to the southeastern United States, destined for local niche market. Promotion, consumer acceptance and consumption of these underutilized carotenoid enriched cultivars may provide a natural therapeutic plant based strategy for type 2 diabetes management.

Southern highbush blueberry (SHB, Vaccinium corymbosum interspecific hybrids) production in Florida is predominantly sold as a fresh product during the high-value early season period of March through May. As blueberry production in Florida and other southeastern U.S. production regions continues to increase, the need for cultivars with superior postharvest longevity will become increasingly important. The objective of this study was to assess the fruit quality changes that occurred during postharvest storage for six SHB cultivars released from the University of Florida blueberry breeding program (‘Arcadia™’, ‘Emerald’, ‘Endura™’, ‘Indigocrip™’, ‘Keecrisp™’, and ‘Patricia’). The six cultivars were harvested on two different dates during the 2015 season, and fruit from each harvest date were stored for 14 days at 5 °C. At days one, seven, and 14, fruit from each cultivar were assessed using a trained sensory panel for firmness, sweetness, sourness, blueberry-like flavor, and unripe-green flavor. Additionally, a sub-sample of fruit were used for instrumental quantification of firmness, soluble solids, and titratable acidity. There were significant differences (P<0.05) between harvest dates for firmness of Arcadia™, ‘Emerald’, ‘Endura™’, ‘Indigocrip™’, ‘Keecrisp™’, and ‘Patricia’. Sweetness of ‘Emerald’, ‘Endura™’, and ‘Indigocrip™’ were significantly different between harvest dates (P<0.05). Unripe-green flavor was significantly different (P<0.05) between harvest dates for ‘Endura™’ and ‘Patricia’. Only ‘Emerald’ was significantly different (P<0.05) between harvest dates for sourness and blueberry-like flavor. ‘Keecrisp™’ was remarkably stable among harvest dates and storage periods, indicating the potential for increased postharvest longevity.

The increased market demand for organic and/or local fresh produce is changing the way food is being grown. For many growers, the implementation of high tunnel production systems
has been effective at increasing yield of numerous crops. However, little is known about the effect of this production system on the quality and shelf life of the product. Our objective was to determine how high tunnel production affects the pre-harvest and post-harvest losses, of organic tomato and spinach compared to the open-field. Two tomato cultivars, ‘BHN 589’ and ‘Cherokee purple’, in addition to ‘Corvair’ spinach were grown at the Kansas State University Olathe Horticulture Research and Extension Center from 2013 to 2015. We utilized a splitplot, randomized complete-block design with six replications and typical production practices for the area. Tomatoes were harvested at pink maturity stage and stored at 12.5 °C and 25 °C for 21 days. For spinach, fully mature leaves were harvested and stored at 3 °C and 13 °C for 18 days. Respiration rate, overall quality, texture, color, as well as nutritional quality were evaluated for both crops during storage. Organoleptic quality was evaluated for tomatoes, and water loss and leaf area was measured for spinach. Pre-harvest losses can include overall crop productivity as well as the proportion of marketable crops grown and both parameters were improved by the implementation of high tunnels. Main effects showed that high tunnel production had 116% higher yield compared to the open-field in 2015 (P < 0.01). Spinach marketability was 82.2% in the high tunnel whereas in the open-field it was 55.9% (P < 0.05), and similar results were seen in tomato in 2014. For both crops, the ones grown in the open-field had higher respiration rates. Spinach grown in the high tunnel had slightly higher overall quality compared to the open-field, and quantitative texture analysis indicated the leaves were tender. ‘BHN 589’ tomato grown in the high tunnel were sweeter compared to the tomatoes grown in the open-field based on lower acidity measurements. The same trend was observed for ‘Cherokee purple’, but only for fruit stored at 12.5 °C. There were no differences for antioxidant capacities in ‘BHN 589’, but were observed for ‘Cherokee Purple’ after 10 and 15 days in storage at 12.5 °C (P < 0.01). Our results indicate that the utilization of high tunnels for organic and/or local production of fresh produce could reduce pre-harvest losses and help growers obtain high quality crops with longer shelf-life.

Specified Source(s) of Funding: USDA NIFA AFRI

9:00–9:15 AM

Enumeration of Chlorine-injured Coliform Bacteria of Shredded Cabbage Stored in MAP

Hideki Izumi*
Kinki University, Kinokawa, Japan

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Kinki University, Kinokawa, Japan

Kouki Taimatsu
Kinki University, Kinokawa, Japan

Ayano Inoue
Kinki University, Kinokawa, Japan

Chlorine-based sanitizer can induce coliform bacteria to be in a non-lethal, injured state. The degree that coliforms were injured sublethally by using electrolyzed water containing chlorine on shredded cabbage was evaluated during storage in a modified atmosphere packaging (MAP) at 5 and 10 °C. The thin agar layer (TAL) method was used to recover and enumerate injured bacteria. Treatment with electrolyzed water containing 20 ppm available chlorine for shredded cabbage reduced the counts of coliforms by 0.5 to 1.1 logs and caused sublethal injury from 42 to 77%. When shredded cabbage with or without electrolyzed water treatment was stored in 3 types of package films with an oxygen transmission rate (OTR) of 500, 3000, and 10000 mL/m²/day/Atm for 5 days at 10 °C and 7 days at 5 °C, the CO₂ accumulated to 15%, 10%, and 5%, respectively, and O₂ was depleted to 5%, 10%, and 15%, respectively, regardless of the treatment and storage temperature. Coliform counts on TAL plates increased from 4.5 to 8.5 log CFU/g during 5 days of storage at 10 °C and increased from 4.5 to 6.5 log CFU/g during 7 days of storage at 5 °C. Chlorine-injured coliforms were not seen on shredded cabbage throughout the storage period at both temperatures, except for the samples on the initial day that had injury ranging from 46% to 83%. Since a preliminary study showed that the chlorine level of 1 to 2 ppm could be effective in sublethally injuring Escherichia coli O157:H7, shredded cabbage was inoculated with chlorine-injured E. coli O157:H7 (percent injury: 45%) by mixture with electrolyzed water containing 1 ppm available chlorine, and then stored in a MAP using 2 types of package films with either an OTR of 500 or 10000 mL.m⁻².day⁻¹. While the packages approached an equilibrium of 5% CO₂ and 15% O₂, in a high OTR film and 15% CO₂ and 5% O₂ in a low OTR film at 5 and 10°C, injured E. coli O157:H7 on shredded cabbage was detected. Injury was 55% in a low OTR film for 5 days at 10 °C and 73% in a high OTR film for 7 days at 5 °C. These results indicated that chlorine-injured E. coli O157:H7 on fresh-cut cabbage were capable of exhibiting different degrees of injury during storage in a MAP regardless of the storage atmosphere and temperature.

Specified Source(s) of Funding: A Research Project to Improve Food Safety and Animal Health sponsored by the Ministry of Agriculture, Forestry and Fisheries of Japan

9:15–9:30 AM

Prolonging Vase Life of Gladiolus (Gladiolus grandiflorus L.) cv. White Prosperity

Malik F.H. Ferdosi*
University of the Punjab Quaid e azam Campus, Lahore, Pakistan

Shagufta Umer
University of the Punjab, Lahore, Pakistan

The experiment was conducted by using following chemicals sucrose, AgNO₃, IBA, sucrose+ IBA in different concentrations. The experiment was performed by 4 treatments each with 3 replications by CRD. In this experiment, two preservatives sucrose and AgNO₃ were used denoted as T2, T3, T4, T5, and T6 in 2% sucrose, 4% sucrose, 6% sucrose, and 50 ppm AgNO₃, 100 ppm AgNO₃, and 150 ppm AgNO₃ respectively. IBA was used as a growth regulator in 25 ppm, 50 ppm, and 75 ppm
Concentrations. Tab water was used for control treatments. The results were very significant for treatments T₃, T₄, and T₅ in most of observations. Because AgNO₃ and sucrose were used in these treatments as preservatives. Vase life of the Gladiolus spikes was maximum in the treatment T₆ and T₃. Days of 50% floret opened was also maximum in treatments T₃ and T₆, hence prolonging the vase life by delaying the growth rate. The trend of water up take g⁻¹ was maximum in treatment T₇. T₈, T₉, because in these treatments IBA was used as a growth regulator, so higher the growth rate higher was the rate of water up take, thus delaying the vase life of the gladiolus spikes. The other treatments also gave results superior to that of control (pure water). In general, treatments with sucrose and AgNO₃ hastened flower opening, but the longevity of the spikes was increased compared to control and resulted in increased vase life.

Specified Source(s) of Funding: University of the Punjab Lahore

9:30–9:45 AM

The Koolkat: A Demonstrational Mobile Cooling Unit to Support the Development of Small and/or Urban Farms

Cary L. Rivard*
Kansas State University, Olathe, KS
Kimberly Oxley
Kansas State University, Olathe, KS
Helena Pontes Chiebao
Kansas State University, Olathe, KS
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Kansas State University, Olathe, KS
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Kansas State University, Olathe, KS

Cooling facilities are a major barrier for small farmers in the central United States. A survey of local growers in 2014 revealed that access to proper storage facilities, especially cold storage, is one of the most frequently encountered challenges for producers to increase local food production and implement Good Agricultural Practices (GAPs). In 2015, we found through follow-up surveys that only 32% of producers have access to quick cooling facilities, and 6% have access to refrigerated trucks. Based on these results, it is clear that more emphasis on cooling infrastructure is needed. Therefore, we built a demonstrational mobile cooler in March 2015, using a box trailer, insulation panels, and a cool-bot system with a 10,000 btu air conditioner. Structurally Insulated Panels (SIPs) were chosen for the insulation and were available locally as re-claimed materials. Unlike polystyrene foam sheets, SIPs have closed cell foam and therefore retain their R-value better during moist conditions. More importantly, the polystyrene foam is not a cleanable surface and therefore does not comply with GAPs. The SIPs we utilized have a painted metal layer on either side, and is therefore compliant. Ten, 5' x 10' panels were used for the cooler. We chose to utilize a 6' x 12' dual axle trailer (5' x 11' cooler), which could accommodate two pallets, in addition to providing substantially more weight capacity due to the second axle. The total estimated material cost for the mobile cooling unit was $6290. Once the cooler construction was complete, we were able to provide knowledge to growers as well as the general public about the benefits of proper storage temperatures. The mobile cooling unit was featured in a number of commercial growers events in 2015–16 including a Postharvest Handling Workshop and the Commercial Fruit and Vegetable Field Day as well as the Great Plains Growers Conference. The ability for growers to be able to see the unit and look at the components has had tremendous impact.

Specified Source(s) of Funding: Kansas Department of Agriculture Specialty Crop Block Grant

Oral Session—Vegetable Crops Management 1

Moderator: Ajay Nair
Iowa State University, Ames, IA

8:15–8:30 AM

Leguminous Cover Crops in Vegetable Cropping Systems and Effects of Seed Inoculation

Ajay Nair*
Iowa State University, Ames, IA
John Krzton-Presson
Iowa State University, Ames, IA
Dana Jokela
Iowa State University, Ames, IA

Legume cover crops such as clovers are planted as winter annuals (6–8 weeks before a killing frost) or as summer annuals (in the spring). In colder climates such as Iowa, summer-annual use of legume cover crops is common as it is a useful tool in vegetable crop rotation planning. The amount of nitrogen a legume cover crop can add depends on biomass generated which in turn depends on temperature, rainfall, and soil fertility status. Also legume cover crops need specific strains of Rhizobium to effectively fix atmospheric nitrogen. In order to generate specific N-credit data under Midwest growing conditions, this study investigated three legume cover crops (crimson, red, and yellow/sweet clover) and evaluated them for the amount of nitrogen they can contribute under inoculated and non-inoculated conditions at the Iowa State University Horticulture Research Station, Ames, IA. Experiment was a randomized complete block split-plot design with cover crops as the whole plot and Rhizobium (inoculation or no-inoculation) as the split plot factor. The highest amount of biomass was produced by red clover (5587 kg/ha) followed by crimson clover (4591 kg/ha). Yellow/sweet clover produced the lowest amount of biomass of 3135 kg/ha. Inoculation of seeds with the Rhizobium significantly increased biomass. Inoculated seeds produced almost 1 1/2 times more biomass than the non-inoculated seeds. Percentage

An asterisk (*) following a name indicates the presenting author.
nitrogen on a whole plant basis was significant for clover species and inoculation treatments. Red clover had higher percentage nitrogen than crimson or yellow clover. Nitrogen percentage in plants was not significantly different between inoculated or non-inoculated treatments. Multiplying biomass generated by N content in the plant provides an estimate of how much N will be added/recycled back into the soil. Nitrogen contribution of red clover was the highest (117 kg/ha) followed by crimson (81 kg/ha) and yellow clover (64 kg/ha). Seed inoculation increased the amount of N contributed by cover crops. Amount of N contributed to the soil by the cover crop is the dependent upon cover crop biomass, amount of N fixed from the atmosphere and N taken up by the plant from the soil. Since percentage N within plants did not differ based on inoculation but yet there was increase in the amount of N contributed, it suggests beneficial effects of inoculation on ability of plants to assimilate nutrients and enhance plant growth.

Specified Source(s) of Funding: Leopold Center for Sustainable Agriculture

8:30–8:45 AM

Managing Cucurbit Downy Mildew (Pseudoperonospora cubensis) with Disease Monitoring and Cultivar Resistance

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In 2014 and 2015, 11 and 14 cultivars, respectively, were evaluated for tolerance to downy mildew. Plots were one row 4.5 meters long and 1.5 meters between beds and arranged in a randomized complete-block design with four replications. Plots were hand seeded (1 seed/hole) at 30 centimeters between plants. Plots were evaluated for downy mildew development from August through the final harvest in October. Foliage was rated weekly on a scale of 0 to 100 (0.0 = no downy mildew; 100 = 100% of leaves infected) for downy mildew development. Arcsine-transformed area under disease progress curve (AUDPC) values for downy mildew were calculated for all treatments. Cucumbers were hand harvested on eleven dates in 2014 and nine dates in 2015. Harvested cucumbers from each plot were weighed to determine total yield. They were then graded into one of five classes, counted and weighed: Fancy, No. 1, Large, Small, and Culls. There were significant differences among the cultivars for both yield and fruit number in both years. ‘Dasher II’, ‘Mongoose’, ‘Python’, ‘Speedway’, and ‘Thunder’ had significantly higher fruit number than ‘Seminis 4220’, ‘Tasty Green’, and ‘Marketmore 76’ in 2014 and ‘Dasher II’, ‘Mongoose’, and ‘Python’ had higher yields than all others in 2015. ‘Python’ had a higher marketable yield than ‘Marketmore 76’, ‘Seminis 4220’, ‘Seminis 8592’, or ‘Tasty Green’ in 2014, but in 2015 most cultivars did not statistically differ from one another. The percentage of marketable fruit in 2014 ranged from 27% to 82%. ‘Python’, ‘Seminis 4220’ and ‘Mongoose’ had a significantly higher percent marketable fruit than all cultivars except ‘Intimidator’ and ‘Tasty Green’ in 2014. In 2015, the percentage of marketable fruit ranged from 43% to 85%. ‘Marketmore 76’ had the highest percentage of marketable fruit, but was not statistically different from six other cultivars. In 2014, ‘Marketmore 76’ and ‘Mongoose’ had significantly higher values under the disease progress curve (AUDPC), which indicates the disease severity was greater for those two. All others were not different from one another. In 2015, ‘Mongoose’ and ‘Marketmore 76’, had the highest values, but they were not statistically different than ‘Speedway’ or ‘Fanfare’. ‘Seminis 4719’ and ‘Seminis 4220’ had the lowest values, but only differed from the four with the highest values.

8:45–9:00 AM

Risk Assessment for Root-knot Nematodes in Lima Beans

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Heather Hickman
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Southern Root-knot Nematode (RKN), Meloidogyne incognita, is a major yield-limiting pest in lima beans (Phaseolus lunatus). Root-knot nematodes are not evenly distributed through fields and population dynamics are fluid making whole field management challenging. The objectives of this research were to characterize RKN distribution in the field in relation to soil factors and to quantify RKN populations and impacts on root infestation of lima beans in order to develop field level risk assessments. Surveys were conducted on eight lima bean fields with a history of RKN in 2013 and 2014 and six fields in 2015. Fields were divided into one-hectare grids and evaluated for edaphic factors, including water capacity (FC), electrical conductivity (EC), depth to hardpan, and pH. Twenty soil cores were taken at a 30-cm depth within each grid for nematode assays. Fields were sampled in fall, spring, summer, fall, and the following spring. Plant growth was evaluated indirectly using NDVI. Second stage RKN juveniles were extracted from soil samples using elutriation and sucrose centrifugation. Greenhouse cucumber seedling bioassays were conducted on grid soil samples and for galling on a 1–10 scale. Test crop roots were evaluated for gall ratings at mid-season and after-harvest. Spring J2 counts were significantly correlated with after-harvested root ratings (P < 0.01, R² = 0.431), whereas bioassays were less predictive (P < 0.001, R² = 0.335). Of the edaphic factors, FC was also correlated with after-harvest root ratings (P < 0.001, R² = 0.111). A model combining spring J2 counts and FC or EC gave best prediction of lima bean galling (P < 0.001, R² = 0.64). This research will be used to develop site-specific RKN management practices for lima beans.

An asterisk (*) following a name indicates the presenting author.
Effect of Native and Commercial Arbuscular Mycorrhizal Fungi on the Development, Fruit Yield, and Phytochemicals of Pepper Plants under a Range of Salinity Conditions

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Arbuscular mycorrhizal fungi (AMF) have been shown to benefit plant growth and productivity and improve plant tolerance to abiotic environmental factors such as salinity. Native AMF (isolated from the Chihuahuan desert) and commercial AMF were evaluated in a greenhouse to determine their efficacy in the alleviation of salinity stress on the growth and yield of Capsicum annuum (chili pepper) ‘Jalapeño M’ and ‘NuMex 6-4’. A factorial experiment design with AMF [native AMF (AMF1), commercial AMF (AMF2), and no AMF] and salinity [electrical conductivity (EC) of 1.4, 4.0, or 8.0 dS·m\(^{-1}\)] with nine plants per treatment was employed. Chili pepper seedlings were transplanted in 7.6-L pots containing Metro-Mix 360 growing medium. While transplanting, twenty-seven seedlings were inoculated with AMF1 or AMF2, 40,000 spores per plant. To facilitate root colonization, Long Ashton solution with 44 mg·L\(^{-1}\) KH\(_2\)PO\(_4\) was applied weekly to control plants, whereas Long Ashton solution with 22 mg·L\(^{-1}\) KH\(_2\)PO\(_4\) solution to inoculated plants. Salinity treatments were initiated 17 days after AMF inoculation and applied weekly for a total of seven times. AMF1 inoculated ‘Jalapeño M’ plants also had similar fruit fresh weight to that of non-inoculated plants.

Specified Source(s) of Funding: USDA Hatch project TEX090450

Horticultural Aspects, Uses, and Composition of Piquin Pepper Plants [Capsicum annuum L. var. Glabriusculum (Dunal) Heiser & Pickersgill]

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In Mexico, piquin peppers [Capsicum annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill] are highly valued horticultural products that have not been fully domesticated due to seed sterility, phenotypic and genetic variability, and disease susceptibility, among other problems. Currently, most of the commercialized piquin peppers are obtained from the collection of wild specimens, causing wild populations of piquin pepper plants to be severely reduced due to overexploitation. In recent years a number of the domestication problems have been successfully overcome, and Piquin peppers can be considered a new crop. The objective of this work is to present a thorough review of horticultural aspects—including phenology, propagation, irrigation, and pest management aspects. In addition, an overview of composition, and uses of piquin peppers in Mexico is also presented.

Anaerobic Soil Disinfestation Effects on Weed and Nematode Control, Plant Growth, Fruit Yield and Quality of Fresh-market Tomato

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Anaerobic soil disinfestation (ASD) represents a promising non-chemical alternative to soil fumigation (SF), demonstrated to be effective against soil-borne diseases, plant-parasitic nematodes, and weeds in several crop production systems. However, limited knowledge is available on the effects of ASD on plant growth, yield, and quality. Therefore, a field experiment was conducted in the spring of 2015, at the University of Florida/Institute of Food Science and Agriculture/South West Florida REC located in Immokalee, Florida.
in Immokalee, FL, to evaluate and compare the performances of ASD and SF on weed and nematode control, plant growth, yield, and quality of fresh-market tomato (*Solanum lycopersicum* L.). Pic-Clor 60 (1,3-dichloropropene + chloropicrin) was used as a SF and compared with two ASD treatments applied using a mix of composted poultry litter (CPL) at the rate of 22 Mg/ha, and two rates of molasses [13.9 (ASD1) and 27.7 m³/ha (ASD2)] as a carbon source. ASD plots reached high anaerobic conditions, and cumulative redox potential was 167% higher in ASD2 plots than in ASD1 plots. Soil treatments showed no significant effect on leaf, stem, fruit, and total plant biomass either on fresh or dry weight basis. Soil fumigation assured the best weed control; however ASD treatments ensured an adequate level of weed control, enough to prevent yield reduction. The application of ASD at both rates assured equivalent or higher level of control of root-knot nematode (*Meloidogyne* spp) as compared to SF. Total marketable yield was 49 Mg/ha in SF plots, and 19.7% and 26.7% higher in ASD1 and ASD2 plots, respectively. Postharvest fruit quality parameters were not influenced by soil treatments, except fruit firmness, which was significantly higher in fruits from ASD treated plots, than in those from the SF treatment. Fruit produced in ASD treatment showed on average 15.6%, 14.6%, and 7.7% higher potassium, calcium, and magnesium and 23.2% lower manganese than those obtained from SF, respectively. Using a mixture of CPL and molasses, ASD can be a sustainable alternative to SF as it provided an adequate level of weed and root-knot nematode control, and it may improve marketable yield and fruit quality of Florida fresh-market tomato.

9:45–10:00 AM

**Late Blight-resistant Tomato Varieties Evaluation in Florida**

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Pamela Roberts

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In Florida, late blight (LB) caused by *Phytophthora infestans* (*P. infestans*), is a destructive disease responsible for entire crop losses in the Solanaceae family such as tomato and potato. *P. infestans* causes large-scale and widespread damages to winter tomato production because of the ideal climatic conditions for the disease development. Tomato varieties resistant to *P. infestans* are available in the market; however, evaluation of resistance levels of these varieties has not been performed in Florida. Therefore, the objective of this study was to evaluate resistant tomato varieties to *P. infestans* on disease resistance, yield, and fruit postharvest quality. The study was conducted in the UF/IFAS Southwest Florida REC in Immokalee, FL, during Spring 2014. Tomato varieties round (FL 47, Defiant PhR, Mountain Merit, and Iron Lady) roma-type (Plum Regal), campary (Mountain Magic), cherry (Jasper) and mini-roma (Juliet) were transplanted on 2 Jan. 2014, into polyethylene mulch fumigated beds. Data collection consisted of LB disease severity ( ), marketable and unmarketable fruit yield, and postharvest quality. Highly susceptible varieties with no resistance genes, FL 47 and Juliet, had 95 and 87%, respectively, of the foliage with LB symptoms. Moderately susceptible Plum Regal was significantly higher than varieties containing both resistance genes but still was greatly reduced in disease severity compared to the susceptible varieties. Tomato varieties containing both Ph2 and Ph3, Defiant, Mountain Merit, Iron Lady, Mountain Magic, and Jasper had less than 10% of symptomatic foliage. Total season marketable and unmarketable yields were not different among LB-resistant varieties (1102 to1369 boxes/acre) and higher than ‘FL47’. Mountain Merit had higher extra-large fruit yield than the other varieties evaluated. The roma-type tomato ‘Plum Regal’ produced 1492 boxes/acre total season marketable yield of which 40% was large fruit category. The cherry tomato ‘Jasper’ produced a total season marketable yields of 134.4 tons/acre with an average fruit size of 5.8 g. However, mini-roma LB-susceptible ‘Juliet’ produced only 2.7 tons/acre total season marketable yields of with an average fruit size of 22.7 g. Campary tomato ‘Mountain Magic’, total season marketable yields was 12.7 tons/acre of which 54% was medium fruit size. Among the round tomato varieties, Defiant PhR and Mountain Merit had higher TSS and pH than Iron Lady. Fruit color was higher for ‘Defiant PhR than for ‘Iron Lady’. Tomato varieties containing both Ph2 and Ph3 had less than 10% LB symptomatic foliage and produced higher marketable yields than susceptible varieties.

**Oral Session—Organic Horticulture 1**

**Moderator:** Suzanne O’Connell

University of Georgia, Athens, GA

10:00–10:15 AM

**Exploring 60-Day Organic Crops for High Tunnels: Turnips and Ornamental Cut Kale**

Suzanne O’Connell*

University of Georgia, Athens, GA

High tunnels can reduce weather-related production risks and provide season extension opportunities however, there is a lack of information about these systems for the Southeast region therefore we evaluated the performance of turnips (*Brassica rapa*, subsp. *rapa*) and ornamental cut kale (*Brassica oleracea*) as potential 60-day autumn crops grown under high tunnels. The trial was a split-plot design with four replications. The main factor was planting date (7 Oct. or 21 Oct.) and the sub-factor was cultivar. Black polypropylene landscape fabric was used as a mulch, automated sidewall curtains were opened when ambient air temperatures exceeded 15.6 °C, and row covers were draped over plants when nighttime temperatures were predicted to be ≤ 0 °C. A mixed ANOVA model analyzed marketable yield data for each crop type. A logistic regression assessed the nonmarketable percentage of yield. The following results reflect the first year of data from an ongoing two-year study. Turnips were harvested over time when individual roots reached

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An asterisk (*) following a name indicates the presenting author.
the target diameter of ≥ 5.1 cm. Both planting date and cultivar type had an effect on turnip root yield. The average marketable root weight as well as the root:shoot ratio was lower for the first planting date compared to the second planting date ($P \leq 0.05$). The turnip cultivars Purple Top White Globe and Royal Crown had a higher root:shoot ratio than ‘Golden Globe’ and ‘Amber Globe’ ($P < 0.01$). The average days to harvest for the first and second turnip planting dates were 66 and 81 days, respectively after direct seeding. For the ornamental cut kale, each block was harvested when a minimum of 75% of plants reached the target height of > 30 cm and when contrasting colors had developed. Both planting date and cultivar type had an effect on kale stem length. The average kale stem length was greater for the first planting date compared to the second planting date ($P < 0.01$). The kale cultivars Crane Bicolor and Lucir White had longer stems compared to ‘Crane Red’ ($P < 0.001$) while ‘Crane Bicolor’ had greater stem and flower diameters compared to the other cultivars ($P < 0.001$). The second planting date had a greater percentage of non-marketable stems, 15% compared to < 1% for the first plant date, primarily related to limited stem length (15%). The average days to ornamental cut kale harvest for the first and second planting dates were 40 and 55 days, respectively after transplanting.

10:15–10:30 AM

Why Do Organic Farmers Decertify?

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Organic food, one of the fastest growing food segments, continues to offer new economic opportunities for farmers in the United States (Greene et al., 2009; Constance and Choi, 2010). The Organic Trade Association (OTA) projects a market growth of at least 14% for the 2013–18 period. According to OTA, the 2010 growth rate of organic food sales was nearly 8%, higher than the growth of total food sales (0.6%). Yet, organic certification remains low in the United States (Greene et al., 2009). Most studies focus on understanding what motivates (or not) farmers to certify. Findings show a wide array of factors related to production, markets, and the certification process (Kremen et al., 2004; Park and Lohr, 2006; Sierra et al., 2008; Park, 2009; Dimitri, 2012; Veldstra et al., 2014). To our knowledge, the literature has not yet conducted large-scale research on what motivates farmers to decertify (Strochlic and Sierra, 2007). This article answers what are the main factors driving decertification among organic farmers. We use a 2012 online survey of 4312 fruit and vegetable farmers from the Food Industry MarketMaker database. The survey includes questions regarding demographics, management, and attitudinal factors. The sample for this study includes 383 farmers, out of which 81 (21%) are no longer certified or started the certification process but did not achieve certification. We use a probit regression to find what are the key factors driving organic decertification. Results suggest that farmers in the Midwest and those facing market barriers are more likely to decertify. It is likely that market access and reliability, especially in the Midwest, are driving farmers to discontinue certification. Experienced farmers and those using university extension services have a lower probability of decertification. An explanation is that providing research-based information and accumulating human capital allows farmers to respond to certification issues. We expect that farmers with more information regarding certification can develop systems to maintain or improve profitability. This article contributes to the literature in two ways. First, we use a unique dataset of fruit and vegetable organic farmers to investigate what drives the choice of decertification. Second, this study bridges the gap in the literature by providing the main factors of decertification. Scholars, extension educators and specialists, and government agencies can use these results to advocate for research-based extension resources that help farmers to face market challenges. Findings demonstrate that policy design should be state- and region-specific rather than national in nature.

Specified Source(s) of Funding: USDA-NIFA

10:30–10:45 AM

Effect of Organic Manures on Biomass, Yield, and Quality of Melon (Cucumis melo L.) Raised on a Heavy Soil

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Soil erosion and pollution on farmlands are the major issues in the field of agriculture. Farmers have accepted organic farming as a healthy alternative and it is the fastest growing sector in the field of agriculture around the globe. As a part of the ongoing conservation research program, over one hundred varieties of Melons (Cucumis melo L.) from around the globe have been analyzed for their quality and adaptability. Selected two varieties of high quality melons, Pride of Wisconsin and Charentais (French variety), were raised on Memphis silt loam soil (Typic Hapludalf, silty, mixed, thermic) in southwest region of Mississippi. These melons received nutrients from three treatments of composted organic manures (cow-C; poultry-P; cow and poultry-C+P) in a split-plot design. The parameters evaluated were leaf area index (LAI), percentage of canopy cover, stem diameter, dry biomass, quality, and yield. There was no significant difference in LAI, and percentage of canopy cover, while
the yield, stem diameter, flesh thickness, and rind pressure were significantly high for ‘Pride of Wisconsin’, dry biomass, °Brix, and number of fruits per hectare were significantly high for ‘Charentais’ on all three treatments of manures. Cow manure results showed melons with highest vitamin C followed by poultry and least in Cow+poultry, but vitamin C levels of melons under three organic treatments were not significantly different. Since both these varieties of melons respond well to these organic manures and are highly adapted to this region, we strongly recommend these manures and varieties for commercial production.

Specified Source(s) of Funding: USDA-NIFA

10:45–11:00 AM

System Effects of Strip Tillage and Compost with Zonal Cover Cropping in Organic Broccoli

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Strip tillage and zonal cover cropping are both strategies that tailor management to specific areas of the field, with the goal of improving system-level performance. As part of a long-term field trial in Michigan, a study was conducted over two seasons (2014 and 2015) to evaluate the effects of tillage and compost on organic broccoli (Brassica oleracea ‘Belstar’) production following zonal cover cropping of vetch (Vicia villosa Roth) and rye (Secale cereale L.) planted in in-row and between-row areas, respectively. Experimental plots were arranged in a split-plot design with tillage as the main plot factor [full width conventional tillage (CT) vs. strip till (ST)] and compost application as the subplot factor (none vs. dairy compost). CT was accomplished using a rototill, while ST was accomplished with a Hiniker 6000 two-row strip-tiller. Effects on broccoli yield and quality, weed pressure, and soil moisture, temperature, and inorganic N availability were evaluated. Conventional tillage and the addition of compost generally increased total broccoli yields. However, in 2015, the physiological disorder brown bead was particularly prevalent in CT treatments, with greater yields of high-quality marketable heads observed in ST. Soil and microclimate measurements suggest that the observed yield benefits from CT and compost application may be more attributable to soil N availability than to differences in soil moisture or temperature. Weeds were managed through a combination of hand weeding and cultivation using a Hillside rolling-spyder cultivator. Increased competition from weeds or cover crop regrowth may have also contributed to depressed yields in ST, but the rolling-spyder cultivator generally proved effective at managing weeds between crop rows, even in the presence of rye cover crop residue. The performance of ST is sensitive to crop, environment, and management. Continued research is needed to identify crop-specific best practices and to better understand production and conservation tradeoffs in organic vegetable systems.

Specified Source(s) of Funding: USDA OREI Grant #2014-51300-22244; The CERES Trust Organic Research Initiative Grant

11:00–11:15 AM

Sequential Transplanting of Parthenocarpic Cucumbers in Organically Managed High Tunnels in Hardiness Zones 7 and 8 of North Carolina

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Fresh market cucumber is a highly profitable crop in high tunnels. However, information on its production in hardiness zones 7 and 8 of North Carolina was very limited. The objective of this project was to determine the best time for planting parthenocarpic (seedless) cucumbers in high tunnels in spring and fall, and to explore the economic potential of the crop in organic managed high tunnels. Seedless cucumber ‘Tyria’ and ‘Socrates’ were tested in high tunnels (30’x96’x5’) located in Greensboro (zone 7) and Goldsboro (zone 8) for Spring and Fall 2014 and 2015. Treatments include three sequential transplanting dates that were 10 days apart starting from 31 Mar. and 27 Aug. 2014, or 2 Apr. and 11 Aug. 2015. Two rows of seedlings were transplanted in each of 30”-wide, black plastic mulched raised bed, with a row spacing of 12” and in-row spacing of 18”. Beds were irrigated with one drip tape (5/8”, 8 mil, 12” emitter spacing) that was buried in the middle of beds under the plastic mulch. The high tunnels were covered with single (Greensboro) or double-layer (Goldsboro) 6-mil polyethylene films. Temperatures inside the high tunnel were managed between 50 °F to 85 °F (optimal 68 °F to 85 °F) through opening/closing sidewalls and applying row covers, when temperatures inside the high tunnel went below 50 °F. The experiment was conducted as a split-plot design with four replications, cultivars being main plots and planting dates as split plots. A total of eight seedlings were planted in each split plot. Results indicated that planting dates around 10 April for spring production or early August for fall production would work best for both zones. For a single-bay high tunnel with two beds (four rows) of cucumber, the estimated gross income was about $6,000, which translates to $18,000 per high tunnel. The
estimated net income was $15,122 or $4.04/ft²/season excluding infrastructure. Our research proved that seedless cucumber could be a profitable crop for organic high tunnels in plant hardiness zones 7 and 8.

**Oral Session—Plant Biotechnology**

Moderator: Ainqong Shi  
University of Arkansas, Fayetteville, AR

10:15–10:30 AM

**An Ethylene-responsive Element Binding Factor Acts As a Positive Regulator in the Antiviral RNA Silencing in Petunia**

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Virus-induced RNA silencing is involved in plant antiviral defense and requires key enzyme components, including RNA-dependent RNA polymerases (RDRs), Dicer-like RNase III enzymes (DCLs), and Argonaute proteins (AGOs). However, the transcriptional regulation of these critical components is largely unknown. We identified an ethylene-responsive element binding factor (PhERF2) that is induced by *Tobacco rattle virus* (TRV) infection in petunia. Inclusion of a fragment in a TRV silencing construct containing reporter fragments of *phytoene desaturase* (*PDS*) or *chalcone synthase* (*CHS*) substantially impaired silencing efficiency of both the *PDS* and *CHS* reporters. Silencing was also impaired in *PhERF2*-RNAi lines, where TRV-PhPDS infection did not show the expected silencing phenotype (photobleaching). In contrast, photobleaching in response to infiltration with the TRV-PhPDS construct was enhanced in plants overexpressing *PhERF2*. Transcript abundance of the RNA silencing-related genes *RDR2*, *RDR6*, *DCL2*, and *AGO2* was lower in *PhERF2*-silenced plants but higher in *PhERF2*-overexpressing plants. Moreover, *PhERF2*-silenced lines showed higher susceptibility to *Cucumber mosaic virus* (CMV) than wild-type (WT) plants, while plants overexpressing *PhERF2* exhibited increased resistance. Taken together, our results indicate that PhERF2 acts as a positive regulator in antiviral RNA silencing and is essential for efficient silencing of genes in plants.

**Specified Source(s) of Funding:** USDA Floriculture Initiative (5306-21000-019-00D)

An asterisk (*) following a name indicates the presenting author.
Genome-wide Identification and Expression Analysis of Apple ASR Gene Family in Response to Alternaria alternata f. Sp. Mali

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The ABA/water stress/ripening-induced (ASR) gene family exists universally in higher plants, and many genes are up-regulated during periods of environmental stresses, and fruit ripening. Although a considerable amount of research has been performed investigating ASR gene responses to abiotic stresses, relatively little is known about their roles in response to biotic stresses. In this report, we identified five ASR genes in apple (Malus domestica) and explored their phylogenetic relationship, duplication events, and selective pressure. Five apple ASR genes (MdASR) were divided into two clades based on phylogenetic analysis. Species-specific duplication was detected in MdASR genes. Leaves of 'Golden Delicious' and 'Starking' were infected with Aternaria alternata f. sp. mali, which causes apple blotch disease, and examined for the expression of the ASR genes in lesion areas during the first 72 h after inoculation. Expression of all five MdASR genes was up-regulated, but only MdASR1 was up-regulated at all sampling time with a highest expression level up to eight times in 'Golden Delicious' compared to 'Starking'. The activities of stress-related enzymes, peroxidase (POD), superoxide dismutase (SOD), catalase (CAT), phenylalanine ammonia lyase (PAL), and polyphenoloxidase (PPO) and the content of malondialdehyde (MDA) were also measured. As the physiological indexes for disease resistance, the maximum activity of these enzymes and MDA content was measured in different stages of disease development in different cultivars. Our research suggests that MdASR1 is very likely involved in biotic stress responses in apple.

Particle Bombardment Transformation of Citrus

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Janice Zale
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The objective of this study was to develop a particle bombardment transformation system for citrus. Plasmid DNA, containing the nptII selectable marker and the gfp reporter, was bombarded into immature citrange rootstock, cv. Carrizo (Citrus sinensis Osb. x Poncirus trifoliata L. Raf.) and transgenic shoots were regenerated. Although the number of independent stably transformed tissues/total number of explants, recorded by monitoring GFP fluorescence four weeks after bombardment was high at 18.4%, the regenerated transgenic shoots was low at 0.7%. Fluorescing GFP-putative transgenic shoots were micro-grafted onto immature Carrizo rootstocks in vitro, confirmed by PCR amplification of nptII and gfp coding regions, followed by secondary grafting onto older rootstocks in the soil. Southern blot analysis using probe from nptII coding region indicated that all the fluorescing shoots were transgenic. The particle bombardment transformation system might be applied to transformation of other citrus cultivars with minimal modification on tissue culture conditions and be appropriate for transformation with minimal cassettes which is a potential method for transformation of clean DNA (free of pest sequence) into citrus genome. This is the first report of biolistics and plant regeneration in citrus.

Genetic Transformation in Citrus: Thinking Outside the Box

Maria Luiza Oliveira*
USDA-ARS, Ft. Pierce, FL

James Thomson
USDA-ARS, Albany, CA

Ed Stover
USDA-ARS, Ft. Pierce, FL

Conventional breeding methods to incorporate resistance in citrus are very slow, due to extended juvenility from seedling trees and multiple generations needed to incorporate resistance from distant relatives. Use of transgenic methods may provide disease resistance in less time. Published protocols have relied on somatic embryogenesis from nucellar calli or from protoplast-derived cultures, or more commonly, shoot organogenesis from juvenile epicotyl or internodal stem segments. However, these Agrobacterium tumefaciens-based systems typically have low transformation efficiencies and low transgenic plant recovery. A number of physiological factors associated with source tissues influence in vitro development and we are exploring alternative explants and treatments, in comparison to conventional methods using juvenile epicotyl stem segments. In Mexican lime, cotyledons provided an improvement in regeneration capacity, longer shoots and more robust rooting, with a very simple transformation procedure, reducing the time required for transgenic plant-recovery. Greenhouse internode explants treated with macerating enzymes prior to Agrobacterium co-cultivation are showing promise in transformation of citrus. In order to assess the effects of macerating enzymes, we examined the effect of different macerating enzymes on the transformation efficiency of Carrizo citrange and Tango mandarin. PCR analyses further confirmed the stable integration of the transgene. Transformation of citrus greenhouse internodes is therefore facilitated when explants are subjected to enzyme treatments prior to Agrobacterium.
infection. This procedure may be broadly applicable, permitting efficient recovery of other citrus genotypes recalcitrant to in vitro transformation.

*Specified Source(s) of Funding:* This research was financially supported by California Citrus Research Board 5200-140A and was also supported by USDA Agricultural Research Service CRIS projects 5325-21000-018, 5325-21000-020, 6618-21000-014-00.

11:30–11:45 AM

**Embryo Specific Expression of a Visual Reporter Gene and the Regeneration of Reporter Gene Expression Free Transgenic Citrus**

Manjul Dutt*
University of Florida, Lake Alfred, FL

Jude Grosser
University of Florida, Lake Alfred, FL

Development of marker free technologies is essential to producing plants that only express the gene of interest without an antibiotic resistance gene that is not acceptable in several parts of the world. As a functional proof of concept, a myb-related transcription factor cDNA, (VvmybA1) was cloned via RT-PCR from Vitis vinifera ‘Ruby Seedless’ berry RNA. The cDNA was introduced into a suspension of Citrus sinensis cv. ‘Hamlin’ cells and Citrus reticulata cv. ‘W Murcott’ cells under the control of a carrot embryo specific gene promoter (Dc:3). A high level of anthocyanin production was observed in developing embryos. By switching gene expression off in germinating embryos, normal transgenic plants were obtained absent of any anthocyanin production. Because this promoter is potentially drought inducible, we conducted stress studies that demonstrated elevated levels of the myb transgene in leaves, but no significant amount of visual coloration. Following this successful demonstration, the myb-related transcription factor ruby cDNA (isolated from the Blood Orange cultivar ‘Moro’) was cloned. This cDNA was incorporated in between sequences obtained from the 5’ and 3’ regulatory regions of a sweet orange derived seed storage protein gene to create an all-citrus construct. This construct was incorporated into citrus cells via a protoplast transformation system developed previously by our program. Phenotypically normal intragenic plants were regenerated using this method. myb-related transcription factor genes provide great potential as a simple and non-destructive visual marker for citrus transformation when coupled with a tissue specific or inducible promoter.

11:45 AM– 12:00 PM

**Challenging Transgenic ‘W. Murcott’ (Nadorcott) Mandarin Containing Xa21 Gene Against Citrus Canker Pathogen**

Ahmad Omar*
University of Florida, Lake Alfred, FL

Mayara Murata
University of Florida, Lake Alfred

Gene transformation offers an attractive alternative to the conventional genetic improvement of Citrus sp. Genetic transformation of several citrus genotypes has been achieved by co-cultivating different explants (mainly juvenile) with Agrobacterium tumefaciens. However, mandarin is considered to be the most difficult Citrus sp. for transformation using the Agrobacterium-mediated system. ‘W. Murcott’ mandarin (a hybrid of ‘Murocct’ and an unknown pollen-parent) is a commercially important cultivar grown in many regions around the world. Protoplast-GFP transformation opens a new avenue to produce transgenic plants especially from seedless or other polyembryonic cultivars not amenable for the Agrobacterium-mediated system. We have produced 10 transgenic lines of ‘W. Murcott’ with plasmid DNA (pAO3), encoding the non-destructive selectable marker GFP (Green Fluorescent Protein) gene and the cDNA of the Xa21 Xanthomonas resistance gene from rice using protoplast/GFP transformation system. All plants are showing stable GFP expression all the time. The PCR analysis revealed the presence of the Xa21 and the GFP genes in the transgenic plants. Molecular characterization including Southern blot analysis and Western blot analysis are showing integration and expression of the transgene in the generated transgenic plants. The Q-PCR are showing different level of Xa21 gene expression among the generated transgenic lines. Transgenic plants will be evaluated against citrus canker pathogen by detached leaf assay (DLA), and by syringe inoculation of attached leaves. Results from these assays will be presented at the meeting.

*Specified Source(s) of Funding:* CRDF

**Oral Session—Produce Quality, Safety, and Health Properties**

Moderator: Manoella Mendoza
WTFRC, Wenatchee, WA

10:15–10:30 AM

**Potential of Industrial Sweetpotato As Livestock Feed in the Southeastern United States**

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Texas A&M University, College Station, TX

Wheeler Foshee
Auburn University, Auburn, AL

Tyler Monday
Auburn University, Auburn, AL

The increased demand of crude oil globally has also increased the production of corn (Zea mays) for fuel ethanol production in the United States. The use of corn for ethanol has in turn increased the price of corn, which is also the primary energy component of animal feeds along with many food products. Stud-
ies were conducted to evaluate the feasibility of using industrial sweetpotato tuberous roots (*Ipomoea batatas*) cultivar ‘Xushu,’ as a substitute for corn as the energy component of animal feed or as a protein source after fermentation and extraction of ethanol. Field studies evaluated the effect of nitrogen fertilizer rates (0%, 50%, 100%, and 150% of recommended amounts) on yield, crude protein (CP), total digestible nutrients (TDN), and acid detergent fiber (ADF) of both fresh industrial sweetpotato tuberous roots and industrial sweetpotato fermentation by-product of these same roots. No differences were observed in yield between the different nitrogen fertilizer rates. Feed analysis revealed that the energy (TDN) levels of fresh sweetpotato were similar to corn, the current standard energy component in commercial livestock feeds. Feed analysis of sweetpotato fermentation byproduct revealed CP levels that were half to two thirds the amount in soybean (*Glycine max*), the standard protein component in livestock feeds. The TDN and CP levels in this research suggest that both fresh industrial sweetpotato tuberous roots and industrial sweetpotato fermentation by-product could be used as an energy and protein source respectively in commercial livestock feeds. Sweetpotatoes were also calculated to out yield corn’s TDN per acre by over 20 times making it an attractive alternative energy component of livestock feed.

10:30–10:45 AM

**Dry Bulb Onion Storage in Sterilized Plastic Crates Compared to Storage in Old Wooden Boxes**

Stuart R. Reitz  
Oregon State University, Ontario, OR

Clinton Shock*  
Oregon State University, Ontario, OR

Harry Kreeft  
Western Labs, Parma, ID

Jim C. Klauzer  
Clearwater Supply, Ontario, OR

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Oregon State University, Ontario, OR

As part of the Food Safety Modernization Act (FSMA), the United States Food and Drug Administration, (FDA) has mandated that produce storage containers be sanitary for their intended purpose. This mandate could potentially lead to efforts to replace wooden storage bins with plastic totes under the assumption that plastic containers would be more sanitary for onion storage. Replicated studies were conducted in 2015 to compare the roles of wooden and plastic storage containers on contamination of onion bulbs with *Escherichia coli*. Onions from five replicated furrow-irrigated plots were harvested using 62.4 to greater than 20,957 MPN (most probable number) *E. coli* /100 ml were harvested into 10 old wooden boxes and 10 sterilized plastic crates. Onions from five replicated drip-irrigated plots using water with 0 MPN *E. coli* /100 mL were harvested into an additional 10 old wooden boxes and 10 sterilized plastic crates. Onions were stored for six weeks and then prepared for shipment through removal of loose skin, roots and soil. None of these packed out onions had detectable *E. coli* on the bulb exteriors or interiors, regardless of storage container type or irrigation water source. Plastic containers did not provide added food safety value compared with wooden bins for the storage of dry bulb onions.

10:45–11:00 AM

**Non-thermal Fresh Food Sanitation By Atmospheric Pressure Plasma**

Robert Morrow*  
ORBITEC, Madison, WI

Robert Surdyk  
ORBITEC, Madison, WI

Ross Remiker  
ORBITEC, Madison, WI

The Non-Thermal Sanitation by Atmospheric Pressure Plasma (NTSAPP) system was developed for sanitizing fresh food on long-duration space missions. Plasmas are ionized gases generated by electrical discharges and composed of electrons, positive/negative ions, neutrons, and other neutral species. One of the most important properties of plasmas is the very high energy that they have, about 3-4 eV, in typical laboratory cold plasmas. Plasma processes are known to be highly effective in promoting oxidation, enhancing molecular dissociation, and producing free radicals and other types of high energies. Non-thermal plasmas provide an effective way to generate extremely reactive species and initiate a variety of chemical reactions of use in surface sanitation of fresh fruit and vegetables. The system operates by passing a carrier gas through plasma jet reactors. The generated plasma then flows with the air through a rotating food sanitation chamber. After passing around the material to be sanitized the carrier gas flows through a scrubber to break down any harmful components prior to being returned to the environment. The system is capable of sanitizing fresh fruits and vegetables in minutes, with minimal consumables and byproducts. The antimicrobial efficacy of an integrated system prototype was tested with several process gases, food items, and microbes. Testing showed that performance with bottled gas mixtures was not significantly better than performance with lab air as the process gas, which has the benefit of operation without pressurized gas lines and with minimal consumables. Tests performed with samples of lettuce, tomato, and radish inoculated with *E. coli* and *Salmonella* showed that fifteen minutes of sanitizing resulted in a 3.7 log reduction of *E. coli* on lettuce and tomato, a 3.2 log reduction of *E. coli* on radish, a 3.6 log reduction of *Salmonella* on lettuce and tomato and a 3 log reduction of *Salmonella* radish. Testing with trained sensory analysis panelists showed the process had no significant impact on taste, olfactory or appearance quality. An alternative configuration using a flat tray system is being developed for commercial applications.

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An asterisk (*) following a name indicates the presenting author.
Evaporative Cooling of Apples: Sunburn Suppression Benefits and Influence on Microbial Survival
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Sunburn is an important disorder when evaluating apple external quality and economic value. In the State of Washington at least 10% of cullage is attributed to sunburn each year. Use of overhead evaporative cooling (EC) can contribute to the suppression of sunburn. Direct water application onto the apple can diminish apple surface temperatures, thus decreasing the chances of sunburn development. However, applying open source irrigation water directly to the apple surface can pose a serious threat to human health if water is contaminated. To evaluate this risk, an apple field inoculation examination was conducted in 2014 to assess generic Escherichia coli (E. coli) die-off rates under realistic apple growing conditions and orchard settings. Weather data were collected to investigate possible relationships between environmental conditions and bacterial die-off rates. Secondly, sunburn incidence for ‘Gala’, ‘Golden Delicious’, and ‘Fuji’ were observed in 2012 and 2013, for two treatments (EC and untreated control) and two canopy locations (high and low). Packout analyses were conducted based on sunburn data results, for the three varieties in both years, using different crop load scenarios. In both years, the use of EC diminished sunburn incidence, except for ‘Fuji’ in 2013. In 2012, EC decreased sunburn incidence by 8.1% for ‘Fuji’, 18.3% for ‘Gala’ and 0.7% for ‘Golden Delicious’. In 2013 untreated ‘Golden Delicious’ and ‘Gala’ apples had 10.2% and 1.6% more sunburn overall than treated fruit, respectively. Untreated ‘Fuji’ apples had 3.5% less sunburn overall than treated. The higher percentage of sunburn on ‘Fuji’ treated with EC is believed to be caused by the discontinuation of water application too early prior to harvest. Overall higher canopy location presented more sunburn than fruit in lower canopy positions. Packout analysis results show that EC increased net returns for all varieties in both years, and in all crop load scenarios. Both EC treated and untreated fruit showed approximately a 2.5 log reduction 8 hours after inoculation (in the absence of light), and a further 1.0 log reduction between 8 and 24 hours. This indicates that overall 99.99% of generic E. coli did not survive the first 24 hours. Evaporative cooling had positive effects regarding generic E. coli die-off rates for ‘Golden Delicious’ and did not negatively impact microbial die-off, considering the weather and water application rates used in this experiment. The possible implications for growers related to new food safety regulations under the Food Safety Modernization Act will be discussed.

Biochemical Characterization of Leaves and Bracts of Poinsettia (Euphorbia pulcherrima Willd. ex Klotzsch) ‘Valenciana’
Maria Colinas-Leon*
Autonomous University of Chapingo, Texcoco, Mexico
Yeni Cuevas-Domínguez
Autonomous University of Chapingo, Texcoco, Mexico

The aim of this study was to evaluate some chemical components of leaves and bracts of the sun Euphorbia pulcherrima Valenciana variety Valenciana for edible purposes. We obtained well-developed leaves and bracts from four plants in the experimental station of the Autonomous University of Chapingo. The samples selected were free of pesticides. First a bromatological analysis was made, considering moisture (M), ash (A), crude protein (TP), etheral extract (EE), and crude fiber (CF). The other variables considered were: anthocyanins, chlorophylls, carotenoids, ascorbic acid, total soluble sugars, soluble protein, total phenolic compounds, antioxidant capacity, using different colorimetric assays. We also evaluated color (Lch) and weight loss. Methods were carried out according to the variable. For data analysis, confidence intervals were evaluated as well as a correlation analysis, considering three replicates. Results obtained within the intervals were: total anthocyanins in bracts were between 7.31–10.38 mg/g, chlorophyll a was of 0.03–14 mg/g, chlorophyll b 0.27–0.38 mg/g, total chlorophyll content in an interval of 0.08–1.67 mg/g, carotenoids from 3.49 to 3.88 mg/g, ascorbic acid in leaves was between 12.63–26.24 and in bracts 37.68–46.88 μg/g, total soluble sugars 7.30–14.31 in leaves and in bracts 0.91–7.96 mg/g, soluble protein in leaves from 0.1–0.83 and in bracts from 0–0.058 mg/g; total phenolic compounds 1.36–1.58 in leaves, and in bracts from 2.93–3.37 mg/g, antioxidant capacity in leaves 7.56–8.82 and in bracts from 7.12–8.45 μg/g. Dry matter content in leaves was of 24.75%, and 18.54% in bracts Significant positive correlations were found between chlorophyll a and total chlorophyll; chlorophyll a with antioxidant capacity, and antioxidant capacity with total phenolic content. The results of the bromatological analysis are similar to those reported for Round zucchini (Cucurbita pepo), flowers.
Although fruit is not a major source of amino acids, fruit containing sufficient amounts of amino acids could be a new source. In this study, we compared GABA and amino acid concentrations in selected fruit species of the Sapindaceae family and determined postharvest changes in GABA and amino acid concentrations in rambutan and longan fruit. 18 amino acids, including nine essential amino acids, and GABA were observed. Our results showed variations in GABA and amino acid profiles of different fruit species including Takhro (Schleichera oleosa), Korlan (Nepheleium hypoleucum), Chammaliang (Lepisanthes fruticosa), Ma huat (Lepisanthes rubiginosa), longan (Dimocarpus longan) cv. Mangkornthong, Rambutan (Nepheleium lappaceum) cv. Rongrean, Lychee (Litchi chinensis) cv. Honghuay, Lychee cv. Kom, Lychee cv. Chakpad, and Lychee cv. Sampaokaew. The highest GABA concentration was found in Takhro at concentration of 92 mg/100 g FW. The best amino acid profiles were found in Lychee cv. Sampaokaew and Chammaliang. A postharvest study measured GABA and amino acid content during a 6-day storage period. GABA levels slightly increased in fruit stored in modified atmosphere packaging at 12 °C and fruit stored at room temperature, but fruit quality was diminished in fruit stored at room temperature. A decrease in aspartic acid content was observed in longan fruit stored at 5 °C. All other amino acids remained unchanged in all storage conditions during storage. GABA concentrations remained relatively constant during 6 days of storage at room temperature and increased by 36% after 6 days of storage at 5 °C. Quality of cold stored fruit was greater than that of the control fruit stored at room temperature. We conclude that GABA and amino acid concentrations depend on species and cultivar, and are also affected by postharvest conditions. Fruit of the Sapindaceae family could be a new source of GABA and amino acids.

11:45–12:00 PM

A Characterization of Pomegranate (Punica granatum) Aril Morphology and Anatomy

Hazel Wetzstein*
Purdue University, West Lafayette, IN
Nadav Ravid
POM Wonderful, Del Rey
Justin Porter
Purdue University, West Lafayette, IN,

Pomegranate (Punica granatum) is highly valued for its health benefits and is marketed as whole fresh fruit, extracted arils, juice, and as an ingredient in a large array of products. The fruit is composed of an outer leathery pericarp that contains hundreds of juice-containing arils. Pomegranate arils have a unique structure and are susceptible to mechanical damage. Understanding the structural characteristics of arils has important implications during fruit handling and in aril extraction. The morphology and anatomy of arils during late stages of development were investigated using light and scanning electron microscopy. Arils are made of a single layer of juice cells that radiate outward from a centrally located seed. Juice cells are tightly packed, polygonal in cross section, and have a thick-walled outer cell surface that is covered by a cuticle. Seed structure and a description of the modified cells that contribute to seed hardness will be described. Aril anatomy as it relates to shear and compression damage will be discussed.

Specified Source(s) of Funding: Purdue University

Oral Session—Pomology 1
Moderator: Mokhlies ELsyy
Purdue University, West Lafayette, IN, USA
10:15–10:30 AM

Male and Female Interaction in Apple: Pollen Tube Growth, Fruit Set, Fruit Quality, and Return Bloom

Khalil Jahed*
Purdue University, West Lafayette, IN
Peter Hirst
Purdue University, West Lafayette, IN

Optimal apple production requires adequate and appropriate pollination and fertilization in order to set fruit, increase fruit quality and productivity. Pollen source, pollen-style interaction and compatibility, and pollen tube growth determine the degree of fruit-set. Despite the importance of pollination, basic information on pollen compatibility and effect on yield is lacking for many commercial apple cultivars. Thus, these experiments were conducted to compare pollinizers in terms of pollen tube growth, fruit set, fruit quality and return bloom. ‘Honeycrisp’, ‘Gala’, and ‘Fuji’ flowers were hand-pollinated by crabapple (Malus floribunda) and Ralph Shay), ‘Red Delicious’ or ‘Golden Delicious’ pollen. Pollen source had a significant influence on pollen tube growth and pollen tube enrichment to the base of the style. ‘Golden Delicious’ pollen had the highest and fastest growth followed by ‘Red Delicious’ and crabapple. Both crabapple cultivars tested were not effective pollinizers for ‘Honeycrisp’ resulting in slow pollen tube growth and low fruit set. ‘Red Delicious’ and ‘Golden Delicious’, however, were adequate pollinizers of ‘Honeycrisp’ apples. Pollen tube growth increased over time after pollination and generally reached the base of the style 96 hours after pollination. Fruit quality attributes and return bloom were generally not affected by pollen source. However, crabapple pollen resulted in the lowest number of seeds per fruit in all cultivars. Seed number was positively correlated with ‘Gala’ and ‘Honeycrisp’ fruit fresh weight regardless of the pollen source. A significant positive correlation was found between pistil number and seed number indicating that reducing pistil number is an effective experimental tool to regulate seed number. Return boom was dramatically decreased with larger individual fruit fresh weight. Likewise, return boom was reduced with increasing seed number per fruit. These results suggest...
that pollen source and seed number per fruit influence fruit set, fruit quality, and biennial bearing potential of ‘Honeycrisp’. This has real world implications for orchard establishment and management.

10:30–10:45 AM

**Floral Induction in Biennial and Annual Apple Cultivars**

Mokhles ELsosgy*

Purdue University, West Lafayette, IN

Peter Hirst

Purdue University, West Lafayette, IN

Apple fruit production is highly dependent on flowering frequency. Irregular flowering can lead to biennial bearing. Biennial (or alternate) bearing is a term used in pomology to refer to trees that have an irregular crop load from year to year. Biennial bearing is challenging for the tree fruit industry. Overcoming biennial flowering is essential for successful annual production of high value cultivars that show the biennial bearing phenomenon. Over the last century many theories have been promoted to explain the source of flower inhibition, but these rarely discussed the source of flower promotion. The flower promoting or inhibiting signal seems to be localized in a specific part of the tree because the apple tree could have parts with high flower density and parts with little or no flowers. Many factors influence apple flowering by affecting the ability of trees to initiate flowering buds annually, such as crop load, bourse length, and seed number. These factors likely affect endogenous factors such as growth regulators and expression of flowering genes. Identifying the source of flowering signals will help us to identify pattern of their expression and identify the genes responsible for flowering initiation. This will help us better understand the flowering process in apple. In this presentation we will explain the dissimilarity in flowering regulation between annual and biennial cultivars and the local effect of fruit weight, seed number, bourse length and leaves on flowering induction. Furthermore, we will explain the effect of leaf anatomy and leaf gas exchange parameters on flowering habits in annual and biennial cultivars.

10:45–11:00 AM

**High Rates of AVG Significantly Delay Ripening and Improve Quality of ‘Cortland’ Apples**

Duane Greene*

University of Massachusetts, Amherst, MA

Aminoethoxyvinylglycine (AVG) is an ethylene inhibitor that has been in commercial use for many years. It is sold as the proprietary product ReTain®. The use has been primarily to retard preharvest drop and to delay ripening of apples thus allowing an orderly sequence of harvest while maintaining overall fruit quality. Initially the amounts used were restricted to relatively low rates due to label limitations and excessive reduction in red color development. The cultivars ‘Gala’ and ‘Honeycrisp’ are being extensively planted and they are harvested in during the same harvest window as older cultivars such as ‘McIntosh’ and ‘Cortland’ making it difficult to harvest high quality fruit in a timely manner. In this study high rates of ReTain® (333 g/acre) were applied to ‘McIntosh’ and ‘Cortland’ at 4 weeks and again at 2 weeks before the anticipated start of harvest. Fruit quality was evaluated periodically during the harvest season. A storage sample was taken and a portion of the ReTain®-treated fruit were also gassed with 1-methycyclopropene (1-MCP, SmartFresh™) prior to storage. After 8 weeks McIntosh apples showed a modest delay in flesh firmness loss but after 12 weeks in storage neither AVG-treated nor 1-MCP-treated fruit was firmer than untreated fruit. Cortland apples received similar treatments as McIntosh. ReTain® applications delayed ripening and firmness loss at harvest. Following storage for 10 weeks both AVG and 1-MCP reduced firmness loss and when both ReTain® and 1-MCP were combined there was a highly significant additive delay in fruit softening. Taste evaluation of fruit treated with both compounds rated significantly higher in several key categories including crispness, flavor, and being overall desirable. The large improvement in fruit quality was primarily attributed to a significant delay in fruit ripening, which allowed the fruit to ripen and to mature during cooler weather conditions that favored enhanced overall fruit quality.

11:00–11:15 AM

**Pedicel Characteristics Effects on Apple Fruit Size**

Peter Hirst

Purdue University, West Lafayette, IN

Seval Taskin*

Purdue University, West Lafayette, IN

Apple fruit size is one of the important quality parameters that determines fruit value. It is well known that many factors affect apple fruit size. These can be categorized as environmental, genetic, and cultural factors. Many studies have been conducted to determine the effect of these factors. The apple pedicel is not only responsible for the physical attachment of the fruit to the tree, but also provides the connection between the fruit and the source of water and nutrients, which are carried into the fruit throughout the pedicel via xylem and phloem. Previous work indicated that the amount of xylem area in the pedicel may play a role in fruit size regulation presumably by affecting regulation of water and nutrient movement through the pedicel. It seems reasonable to propose that the pedicel may have a role in regulating apple fruit size. Therefore we sought to determine the effect of apple pedicel size (length and diameter) and anatomy on final fruit size. We compared ten genotypes differing in fruit size potential in terms of pedicel size and anatomy. These comprised crabapple, ‘Gala’, ‘Gold Rush’, ‘Golden Delicious’, ‘Honeycrisp’, Malus floribunda, ‘Pink Lady’, ‘Pixie Crunch’, ‘Pristine’, and ‘Silken’. Fruit size at harvest ranged from 5.4 g (crabapple) to 459 g (‘Honeycrisp’). Among the genotypes, pedicel volume was positively correlated with fruit volume. However, pedicel diameter was more strongly positively re-

An asterisk (*) following a name indicates the presenting author.
lated to fruit volume but pedicel length was negatively related. Therefore, genotypes with larger fruit size also had pedicels with larger diameter but shorter length. Such characteristics would be expected to offer lower resistance to flow than long, thin pedicels. Future work will examine pedicel anatomy and measure flow resistance directly.

11:15–11:30 AM

**Targeted Metabolic Profiling of Apple Fruit Development in Response to Reduction of Crop Load**

Shan Jing*
University of Georgia, Athens, GA
Anish Malladi
University of Georgia, Athens, GA

The apple fruit is a typical pome fruit with the accessory fruit (cortex) developed from the hypanthium or floral cup, and the true fruit developed from the ovary (within the pith). The growth and development of fruit is associated with changes in a variety of metabolites such as sugars, sugar alcohols, organic acids and amino acids. However, the relationship these major metabolites and spatial patterns of fruit growth is poorly understood. Further, the effects of crop load reduction on the distribution and concentration of these metabolites are not completely understood. Here, the spatial changes in these metabolites during different stages of apple fruit development and in response to hand-thinning were studied using gas chromatography. The concentrations of major sugar, sugar alcohol, and organic acid were evaluated for the cortex and pith tissue of the thinned and un-thinned ‘Golden Smoothee’ at nine developmental stages. Fruit diameter and length of the hand-thinned apples were significantly greater than those in the controls from 19 days after thinning. However, no significant difference was observed between the thinned and un-thinned apples in terms of the concentration of major sugars, sugar alcohols and organic acids such as fructose, glucose, sucrose, sorbitol, and malic acid, indicating that the concentration of these metabolites was not affected by reduction in crop load, although higher quantities of these metabolites were present within the total fruit. However, asparagine, a major translocated form of nitrogen, was significantly lower in the thinned within the total fruit. However, asparagine, a major translo

11:30–11:45 AM

**IMapple: A Functional-Structural Growth and Fruiting Simulation Model of ‘Golden Delicious’ Apple Trees**

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Marerk Fiser
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Functional-structural modeling is a useful approach to explore the integration of factors that influence growth and development. Such models may allow us to test hypotheses and conduct virtual experiments much more quickly and efficiently than traditional field-based approaches. Combining knowledge from fields such as plant biology, computer science, and applied mathematics is required for the development of functional-structural plant models (FSPMs). Functional-structural plant models refer to simulating the development of plant structure considering plant physiology, genetics, environmental factors and management interventions with the objective of capturing the plant structure (3D shape) and function. From a horticultural perspective, appropriate orchard design and efficient management practices can be investigated using this approach. We have developed the IMapple (Interactive Model for Apple) by combining expertise from horticulture and computer science. Initially we have focused on developing a model that describes growth and fruiting of ‘Golden Delicious’ apple trees growing on G16 rootstock in Indiana. Inspired by the L-PEACH model, we have restated the underlying model and IMapple has been developed de novo in C# code using data from our results and from the literature. Where adequate data are lacking we have made some assumptions, which over time we hope to replace with data. Our model uses contemporary algorithms from computer graphics. We simulate various environmental factors, such as illumination and gravity. A simulation of one year tree development with the time step of one hour can be executed within a couple of minutes on a desk top computer. The model is representative of real tree growth and development, and will likely be useful as a tool for researchers, instructors, students and growers.

11:45–12:00 PM

**Innovations in Mechanical Harvest for Cider Apples**

Travis Alexander*
Washington State University, NWREC, Mount Vernon, WA

An asterisk (*) following a name indicates the presenting author.
Cider apples are predominantly harvested by hand in the United States, and in Washington hand harvest accounts for 38% to 46% of the total annual variable costs when a cider orchard is in full production. In the United Kingdom, which is the world’s largest producer of cider, cider apples are almost exclusively harvested by machine, utilizing a shake-and-sweep system. A proof of concept study was carried out at Washington State University NWREC in Mount Vernon, to evaluate the suitability of mechanically harvesting ‘Brown Snout’ specialty cider apples utilizing a shake-and-catch system. The study assessed the impacts of harvest method and storage time on yield, fruit integrity, and juice quality characteristics. In 2011 and 2012 the harvested fruit were cold stored (0 °C) for up to 4 weeks, and in 2014 and 2015 the harvested fruit were ambient stored (average of 14 °C) for up to 4 weeks, “sweated.” For 2014 and 2015, the average yield (kg/ha) of the mechanical harvester was 74% that of the hand harvest yield for fruit retained by the machine and 81% when fruit that fell out of the machine were included. Under barn storage conditions, the percent of fruit lost to rot was greater for machine harvest than for hand harvest, and increased for both methods over time; percentage of rot doubled from 2 weeks to 4 weeks storage for machine harvest (from 22% to 41%) and while negligible, tripled during the same period for hand harvest (from 0.7% to 2.1%). The percent fruit bruised and cut were greater for machine harvest (97.5% and 25.5%, respectively) than for hand harvest (47% and 0.5%, respectively), on average for 2014 and 2015. Juice quality characteristics did not differ due to harvest method, but did differ due to storage time. Soluble solids concentration (SSC, °Brix) and specific gravity (SG) did not change due to storage in 2014, but in 2015 both were greater after storage (15.00 and 1.062 on average, respectively) than at harvest (13.31 and 1.056, respectively). pH increased in 2014 from 4.04 at harvest to 4.11 on average after storage, but there was no difference in pH in 2015. Titratable acidity (TA, malic acid g/L) decreased in 2014 from 2.98 at harvest to 2.70 on average after storage, but did not differ due to storage in 2015. Both years tannin (tannic acid %) tended to increase after storage, and on average was 0.14 at harvest and 0.16 after storage.

Specified Source(s) of Funding: WSDA, WSU Agricultural Research Center, WSU CSANR, NARF, WSU Extension

12:00–12:15 PM

Integrating Crop Load Management with Disease Control in an Organically Managed Apple Orchard

Gregory Peck*
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An asterisk (*) following a name indicates the presenting author.
Secondary embryogenesis is the process by which somatic embryos (SE) arise from other embryos and is used to provide sufficient target tissue for gene insertion experiments. Unfavorable traits of Vitis vinifera and Vitis rotundifolia such as susceptibility to disease, a thick exocarp, bitterness and presence of seeds in the former, may be altered via the use of biotechnologies such as somatic hybridization, recombinant DNA technology, or a combination of these techniques. Development of needed biotechnological techniques, however, may be limited due to the lack of certain resources, like adequate target tissues (somatic embryos), which is the subject of my research.

To conduct experiments aimed at improving secondary SE, a two-step medium procedure was premeditated using different first and second media. Existing somatic embryos of the Euvitis cultivars, Thompson Seedless and Sauvignon Blanc, plus the Muscadina cultivars, Alachua and Fry, were cultured for a three week period onto three media types, DM, DM7 and DM14, then examined for callus. After the first three-week culture period on DM, DM7 or DM14 medium, Euvitis cultivars were placed on X6 and Muscadina cultivars were placed on DMX. Prior to their transfer to DMX and X6, calluses had begun to emerge. Once calluses were transferred to the second medium, more somatic embryos were produced by Muscadinia cultivars, on DMX medium than Euvitis on X6 medium. Results from this work will be used to quantify cultivar response and determine efficacy of somatic hybridization and recombinant DNA techniques to improve production of secondary SE and ultimately improve genetic traits of grape for commercial production.

12:00–12:15 PM

**The Effect of Calcium Chloride Sprays on Botrytis cinerea Infection of Petunia xhybrida Flowers in the Postharvest Environment**

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Botrytis cinerea causes rapid decay of Petunia xhybrida flower petals in the postharvest environment. The objective of this experiment was to find alternative methods to improve resistance of petunia flowers to botrytis growth. Four concentrations of calcium chloride (0, 400, 800, or 1200 ppm) spray applications were made to flowering petunias over two weeks. A fungicide application (cyprodinil and fludioxonil) (0.45 g/L) provided an additional control. Twenty-four hours after the final calcium chloride application, flowers were removed from the plants and placed into a chamber (six flowers per chamber) with 99% humidity and inoculated with a conidial suspension (1x 10⁶ conidia/ml). The botrytis isolate used was resistant to the two fungicides. Data were collected on the progression of the fungal disease for 72 h at 12-h intervals. Flowers were scored using a 1–9 scale based on disease progression, with 1 = minimal necrosis and 9 = complete loss of tissue integrity. The calcium chloride application of 1200 ppm had the highest resistance to botrytis infection with a disease severity score of 2 after 72 h following inoculation. In comparison, the calcium chloride 800 ppm treatment had disease severity score of 7 at 72 h. The fungicide treatment proved least effective with a score of 9 at 72 h. These results demonstrate the potential benefit of calcium chloride spray applications for the management of botrytis infection during the post harvest of flowering petunias.

*Specified Source(s) of Funding*: American Floral Endowment

12:15–12:30 PM

**Effects of Light Quality on the Morphology, Growth, and Quality of Common Microgreens**

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Chieri Kubota
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Mark Kroggel
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Microgreens are young seedlings of vegetable or herb species. Microgreens have created an emerging market in the food industry focusing on their high value. However, while microgreens are often grown under sole source electric lighting such as LEDs, limited information is available on effects of light quality on microgreens. Our study focuses on optimizing light quality for different microgreens to achieve desirable quality attributes and to improve the yield. Three microgreen species, ‘Korean Perilla’ (Perilla frutescens var crispa), ‘Savoy Tatsoi’ [Brassica rapa (Narinosa group)] and ‘Red Acre Cabbage’ (Brassica oleracea var capitata) were used in this study. The preliminary experiment was performed in a growth chamber set at 22 °C air temperature. The plants were grown under blue (469 nm, B) and red (661 nm, R) LEDs of 50:50 B:R or 30:70 B:R ratios. Another group of plants were also grown under white/UV-A LEDs with 47:25 B:R ratio or under cool white fluorescent (CWF) light (34:25 B:R). The DLI was 12 mol·m⁻²·d⁻¹ for all treatments. Photosynthetic photon flux (PPF) was 210 μmol·m⁻²·s⁻¹ (16 h photoperiod) for all treatments except for White/UV-A (144 μmol·m⁻²·s⁻¹ for 21 h). The plants were harvested after 90% of their true leaves emerged, approximately 10–17 days after planting. All plants grown under white/UV-A or 50:50 B:R light increased hypocotyl length by 39% to 54% compared to those under CWF light. The hypocotyl length of plants grown under 30:70 B:R light was not significantly different compared with that under CWF light. In both Brassica species, plants grown under white/UV-A light showed greater...
fresh weight than other treatments. This, however, was likely
due to increased water content as their dry weight was similar
to or less than other LED treatments. Light quality did not have
a significant effect on the growth of Perilla. Of interest, the
flavor of Brassica microgreens seemed to be correlated with
the plant growth and morphology. Brassica that had a greater
plant dry weight and a stronger flavor under 30:70 B:R or CWF
light than under 50:50 B:R or white/UV-A light. In contrast,
Perilla had an overwhelmingly strong flavor under 30:70 B:R or
CWF light compared to those under 50:50 B:R or white/UV-A
light. These results indicate the need for species specific light
qualities for microgreens. Further research would be necessary
for other types of microgreens.

12:30–12:45 PM

Evaluation of the Response of Eight Tomato
Cultivars to Early Applications of Uniconazole
for Height Control in Containers
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James E. Barrett
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Carolyn A. Bartuska
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Excess elongation of tomato (Solanum lycopersicum L.)
seedlings grown in containers for distribution to retail garden
centers can impact market value. Uniconazole is labeled for
use on tomatoes in the United States at concentrations of 2–10
mg·L−1 when applied at the two to four leaf stage. The objective
of this work was to evaluate multiple cultivars to determine the
response of earlier application times at lower concentrations.
The cultivars were Better Boy, Brandywine, Goliath, Homestead, Patio, Roma, Solar Fire, and Supersweet 100. Two
trials were conducted in the spring of 2015 using 0.25 to 4.0
mg·L−1 applied 1 day after sowing the seed. Spray volume was
300 mL·m−2. Plant height data were taken 4 and 6 weeks after
sowing. Uniconazole reduced elongation of all the cultivars
and the effect increased as concentration increased. There was
a significant interaction between cultivar and concentration.
‘Patio’ has a naturally short habit and Uniconazole had greater
effect on ‘Patio’ compared to the other cultivars. ‘Supersweet
100’ was less sensitive and about four times as much chemi-
cal was needed to achieve desired height control. The other
six cultivars had a generally similar response to Uniconazole
and good height control was achieved with 0.25 to 1.0 mg·L−1.
These results indicate that commercial growers potentially can
reduce the amount of chemical used on tomatoes with early ap-
plication times to compare the results of the early application strategy
with the current label guidelines.

12:45–1:00 PM

Water Regulation of Unrooted Cuttings in
Propagation
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Water demand of unrooted cuttings changes during the first
week in propagation prior to the visible appearance of callus
issue or adventitious roots. This phenomenon is well-known
by commercial propagators who alter their mist schedule daily
during the first week in propagation to adjust to the changing
water requirements of the cuttings. A series of experiments
were conducted to quantify this phenomenon and to elucidate
the mechanism for water regulation of unrooted cut-
tings. The effect of cutting age on water loss was determined
using Osteospermum cuttings that were placed on a propagation
bench for 1, 3, 5, or 7 days, then removed from the bench and
allowed to wilt. Time to wilt decreased as the age of the cuttings
increased from 1 to 7 days. Water loss rates were confirmed
with stomatal conductance measurements that demonstrated a
7-fold increase in water loss of 1-day old cuttings compared
to 7-day old cuttings. Stomatal aperture changed from 11.5 to
8.5 µm following transfer of cuttings from the mist propaga-

Specified Source(s) of Funding: USDA-ARS Floriculture &
Nursery Research Initiative
Globalization of Coastal Roots: A School-based Urban and Coastal Plant Nursery and Stewardship Program—Challenges and Success
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Pam Blanchard
Louisiana State University, Baton Rouge

Globalization of a domestic program to South America raised many challenges. Language barriers were overcome by including colleagues fluent in both Spanish and the culture of Chile. School calendars were opposite of Louisiana schools allowing for student exchanges and teacher collaboration. Administrative support between elementary schools, middle, and high schools proved to be beneficial. Service learning opportunities for upper grades to work with 1st graders were widely appreciated. Nursery construction methods were initially a challenge due to a difference in metric and English pipe sizes and other plumbing supplies. Our first nursery was primarily shipped from Louisiana to Chile with few exceptions. Cost of shipping and getting items through customs raised many challenges. Eventually we were able to find most of our supplies in Chile at a local supply house. Translating the name of the components for the nursery was difficult during the first nursery installation. This was alleviated by compiling a list of materials with both English and Spanish names and pictures of each item. Costs of materials were at least 50% greater when purchased locally, but these costs were cheaper than shipping. We now carry essential components not found in Santiago for the nursery in our carry-on luggage. The complexity of making local arrangements and plans was facilitated using Skype and using a liaison acquainted with the local schools. The students at the four schools in Santiago and Concepcion, Chile, are the highlight of our efforts. Teachers and administrators have become part of a global community sharing their knowledge and local connections. Faculty and graduate students at the University of Concepcion have become engaged in the program assisting with recommendations, seed donations and planting sites. Cooperative research efforts are currently being planned. This summer we are preparing the first Chilean teacher workshop in Santiago, Chile. A current Louisiana State University graduate student is completing a Spanish version of our Coastal Roots program manual. She is a former graduate from a participating high school in Concepcion, Chile. This will greatly expand the effectiveness of our program in Spanish speaking countries. The expansion of Coastal Roots has broadened this program and also the minds and opportunities for each of our participants.

People’s Awareness, a new female farmers’ group in Shankapur, Nepal, participated in a biofertilizer and off-season vegetable production study as a capacity building tool for improving food security. Shankapur is a terraced, mid-hills village in the district of Syangja, a well-known (Citrus reticulata) ‘mandarin pocket’ designated by the Ministry of Agriculture (MOA). Farmers in Shankapur primarily grow mandarin for commercial markets, but the reliance on one crop leaves some families vulnerable to market fluctuations. Creating a farmers’ group can possibly empower female farmers and improve household and regional food security by increasing opportunities for educational trainings, improved agricultural techniques and technologies such as biofertilizers. Off-season vegetable production is one means to diversify farms from mandarin. Most People’s Awareness members were unfamiliar with growing off-season vegetables through monsoon season (June–August). The first objective of the study was to understand the challenges for members of People’s Awareness, and their satisfaction level of off-season cauliflower production through face-to-face interviews administered twice during the growing season. Participatory observation was also used as a way to collect supportive data from the field. The second objective was to determine the on-farm efficacy of growing off-season cauliflower, Brassica oleracea ‘Remi’. Cauliflower demonstration plots also tested two different types of biofertilizer: 1) water buffalo urine diluted with water and 2) jholmol (urine, manure, wood ash, Tagetes sp. and Artemisia) diluted with water. Jholmol biofertilizer efficacy is largely antitodal despite being promoted by non-governmental organizations (NGOs) in Nepal. Biofertilizer treatments were applied via foliar application; control plots received only water. Leaf samples were collected one week before harvest and analyzed for macro and micronutrient content at New Mexico State University. Cauliflower heads were blanched and harvested from 21 Nov. to 3 Dec. 2015. Interview results indicated that People’s Awareness members were satisfied with the amount of off-season cauliflower produced at the demonstration site; however, when they attempted to produce at their homes, some faced insect infestations (primarily cutworm from the Noctuidae family) and shading from mandarin trees. Leaf tissue samples indicate minor deficiencies in micronutrients, but there was no evidence that either biofertilizer treatment improved the fertility or yields of off-season cauliflower over untreated control plots.
Still, based on these results, off-season vegetable production may be a viable option for improving food security and household income if Nepali female farmers can overcome insect and shade challenges.

2:15–2:30 PM

**Optimum Planting Density for Rainfed Production of Chaya (Cnidoscolus aconitifolius)**

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Spinach tree or chaya (Cnidoscolus aconitifolius Mill.) is a fast-growing, leafy perennial Mesoamerican euphorbiaceous. The promising crop is an excellent source of proteins, vitamins, minerals, and antioxidants. Chaya has also a great potential as medicinal plant (cure of diabetes). Additionally, the shrub can be grown on a widespread number of soil types and tolerates diverse climatic conditions (as long as it is hot enough). This makes the spinach tree, which currently has no commercial relevance, one of the most underestimeted and underutilized horticultural crops; a sustainable production system for chaya needed to be developed. In José María Morelos, central Yucatan Peninsula, Mexico, from 2014 to 2015, a research was done in order to determine the optimum planting density for cropping this potential “super-crop”. In a randomized block system, a density of 10,000 chaya plants/ha was compared to 5000 plants/ha (as monocrop and associated with Hibiscus sabdariffa L.).

The management was based on local resources and rainfall. Clones of the locally popular so-called sweet chaya phenotype (few stinging hairs) were established in rows at 2 m equidistance (with 1 m, respectively 0.5 m distances in between the rows). The effect of these arrangements on the development of chaya was evaluated by measuring parameters regarding vegetative growth and development of foliar (harvestable) biomass. Especially in the second cropping season after establishing chaya, foliar size and number were superior at a density of 5000 chaya plants/ha. As for further vegetative growth, a similar pattern was observed, with the exception of plant height, which was equal in both variants. In this arrangement, intercropping Hibiscus sabdariffa had no positive effect on both, foliar production and other parameters of vegetative development.

2:30–2:45 PM

**Alternative Methods for Harvesting and Field-packing Mandarin (Citrus reticulata Blanco) Fruits in Tanzania**

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Theodosy J. Msogoya
Sokoine University of Agriculture, Morogoro, United Republic of Tanzania

Tanzania ranks second after Kenya in production of citrus fruits in East Africa. The Tanga, Morogoro and Pwani regions are the major citrus producing regions in the country. Mandarin and sweet oranges are among the major economic crops in the regions. Compared to developed countries, where the majority of fresh fruit losses tend to occur at the consumer level, most losses in Tanzania occur during harvest, shipping and marketing. Despite the delicate nature of mandarin fruits, harvesting is traditionally done by the pick-drop-catch (PDC) method after which the harvested fruits are bulk-loaded onto grass cushioning in a flatbed truck for shipping. This study compared fruit quality of 1) fruit harvested using the PDC, Ladder Plus Bag (L+B) or Cutting Pole (CP) harvesting methods, and 2) three field-pack methods: bulk (BULK), bamboo-baskets (BAMB) and stackable, plastic crates (SPCR). Fruits harvested using the PDC method were packaged and shipped by truck to simulate local shipping conditions. Additional fruit harvested using the three harvest methods were packed in foam cushioned SPCR for storage evaluation. At harvest, fruit culls were lower using L+B (4.4%) and PDC (6.4%) than with CP (19.6%). Fruit stem plugging was >6% higher with CP than with PDC and L+B methods. CP required 30 minutes more than the other methods to fill a 300-fruit capacity SPCR. CP-harvested fruit also had >4% more decay than L+B or PDC during subsequent storage at ambient temperatures. Fruit decay after 9 d of storage was higher with BAMB (32.4%) than SPCR packaging (24.5%); decay with BULK was not different (29.6%). Most of the decayed fruits with SPRC were located on the top while for BAMB most were from middle position of the package. L+B and SPCR show promise as alternative harvest and packaging practices for reducing postharvest loss of mandarin fruit along the value chain in Tanzania.

2:45–3:00 PM

**Iran Horticulture Potential: A Great Opportunity for Current and Future International Collaborations**

Kazem Arzani*
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An asterisk (*) following a name indicates the presenting author.
It has been discovered during the past twenty years attending International Horticultural Congress (IHC), Symposium, Conference and Workshops in different countries, and also recent sabbatical leave at Cornell University, a substantial number of international colleagues showed high interest for visiting Iran as a historic country in general, and also in specific, wanted to be familiar with Iran horticulture industries potentials. In order to discuss on Iran horticulture potentials, possible limitations and scientific solutions on the problems, and also possible future collaborations at the national and international scale, it has been developed a proposal and suggested that “First International Conference and 10th National Horticultural Science Congress of Iran (IrHC2017)” held in 2017 at Tarbiat Modares University (TMU), Iran. Proposal already approved by TMU, Iranian Society for Horticultural Science (IrSHS) and Ministry of Agriculture of Iran as main organizers. In addition, the proposal sent to International Society for Horticultural Science (ISHS) and approved for better introducing Iran horticulture potentials to international delegates and wider exchange of knowledge. The Iran Horticultural Science Congress (IrHC) held every two to four years since 1996 at different cities of Iran, usually attracting 500 to 1000 delegates. According to the statistics, horticulture is one of the most important agriculture industries in Iran. The overall climatic condition of the country is temperate, although there are many microclimates with wide diversity throughout the country. In addition, Iran enjoys specific geographic conditions such as benefiting from approximately 250 sunny days per year, the capacity for cultivation of numerous horticultural crops throughout the country. These features make it possible to produce high quality of various horticultural crops, e.g. Iran’s horticulture sector consists of 2.5 million ha orchards with annual production of more than 15 million tons of fruit. In addition of 800,000 ha of vegetable crops, floriculture as well as medicinal plants. Also, Iran is center of origin for various horticultural crops and is a rich country in specific native germplasms such as Persian walnut. The quality of some Iranian products, especially dates, pistachios, figs and pomegranates, for which the country holds first position in the world. Therefore, Iran has a good potential for increasing both the quality and quantity of horticultural crops to provide the world’s horticultural markets with a wide diversity of horticultural products. The potentials, possible limitations and problems for Iran horticulture industry and also the opportunity attending IrHC2017 at TMU in Iran will discuss.

 Specified Source(s) of Funding: I would like to thank Tarbiat Modares University (TMU), Iran for financial assistant attending ASHS-2016 Annual Conference.

Oral Session—Computer Applications in Horticulture

Moderator: Kurt Nolte
University of Arizona, Yuma, AZ

1:45–2:00 PM

Getting Started Using a UAV for Generating Field Imagery: Creating Orthomosaic Images

Rosa Bevington*
University of Arizona, Yuma, AZ

Kurt Nolte
University of Arizona, Yuma, AZ

An orthomosaic is an aerial panorama that has been generated using computer software that geometrically corrects and connects overlapping images to make a uniform photograph. Unlike uncorrected aerial photographs, an orthophotograph can be used to gauge true distances, because it is a true representation of the Earth’s surface. We use orthomosaics to better understand management practices for agricultural producers by surveying fields for irrigation water distribution, plant health assessments, field plant stand counts, and plant growth determinations. There are many different programs available to make these types of pictures. We have used free programs such as Microsoft Image Composite Editor (ICE), moderately priced programs such as Stitcher 4 and a higher priced program, Agisoft Photoscan. We found that Photoscan is a robust program that can import large numbers of field pictures, required for large fields when captured by a small UAV (Unmanned Aerial Vehicle) platform. Microsoft Ice and Stitcher 4 are able to complete an orthomosaic rendering that contains a small set of pictures but at times struggles with larger image sets. This presentation will review the basic steps in generating an orthomosaic from a small collection of images that were captured by a UAV. While all software programs discussed in this presentation can generate orthomosaic imagery, careful consideration must be employed when selecting an appropriate program to utilize.

2:00–2:15 PM

Using Free Fiji Image J Software to Generate NDVI Images in Horticulture from UAVs

Kurt Nolte*
University of Arizona, Yuma, AZ

Rosa Bevington
University of Arizona, Yuma, AZ

As agricultural technologies expand toward the use of Unmanned Aerial Vehicles (UAVs) for aerial image capture, users have a need for resources that guide first-time pilots critical tips for making superior images. FIJI Image J is a free, open source software package that is capable of producing robust NDVI (Normalized Difference Vegetation Index) images captured from still cameras that can be mounted on UAV (Unmanned Aerial Vehicle), or other, platforms. This presentation provides a basic overview of the steps involved in generating a NDVI image through the use of FIJI Image J.

An asterisk (*) following a name indicates the presenting author.
Developing and Parameterizing the Cropgro Model to Simulate Strawberry Growth and Production

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Strawberry (Fragaria xananassa) production in Florida is the second largest in the United States amounting to 200 million pounds from 11,000 acres with a production value of 300 million dollars in 2014. However, there has been little attention to modeling strawberries, despite the economic importance of the industry. The objectives of this study were to adapt the CROPGRO model for simulating strawberry growth and development by providing cardinal temperatures and process information from literature, along with optimizing additional parameters with a hybrid Metropolis-Hastings-Gibbs algorithm. This information and parameter values in the CROPGRO-Strawberry model influence crop development, daily dry matter (DM) production, fruit set, and DM partitioning. The model was evaluated with field experimental data collected in Wimauma, FL, from October 2014 to March 2015. Input information consists of weather, soil, irrigation and fertilizer management during the growing season. Two cultivars, Florida Radiance and Sweet Sensation, were grown in six replicates. Plants for each cultivar were randomly sampled for destructive measurement of dry mass of leaves, petioles, roots, seeds, and fruits at biweekly intervals. Leaf area, width and height of plants were measured to parameterize canopy photosynthesis in the model. Fruits were harvested twice per week to measure the fresh weight, dry weight, numbers, and sizes of harvested fruits. CROPGRO already has code for predicting fresh weight, dry matter concentration, size, and maturation of tomato fruits so new parameterization will be introduced for strawberry fruits. After adaptation, the developed model will predict yield response to changes in weather, soil water supply, N supply, and crop management practices. The developed model can be a valuable tool for modeling strawberry production response to weather variability or climate change.

A New System to Collect and Save Data on Fruit Trees in Germplasm Collection Based on Radio Frequency Identification Technology

Petra Engel*  
CREA—Council for Agricultural Research and Agricultural Economy Analysis, Rome, Italy

The process of characterization and data management of fruit tree collections is often lengthy, due to several aspects, such as the precise identification of the accessions in the field, acquisition of a wide range of phonological, agronomical, and pomological information, transfer of data to electronic devices and their subsequent elaboration. In order to efficiently face these obstacles and to reduce overall time investment, the CREA-FRU, in collaboration with IT experts, has put in place a hardware–software system for data acquisition, storage, management, and updating by means of the RFID technology (Radio Frequency Identification). The system consists of a front-end interface for application in the field (Tablet PC), and a back-end interface that allows to download the newly-entered data into the database located on a server. Communication between the reader RFID, Tablet PC and the UID (Unique Identification Number of the single accessions, attached to the trees by a TAG) works via Bluetooth and links all data to the respective accession. At the front-end, the operator is equipped with the Tablet PC and the RFID reader, which allows him to track and identify an accession, add a new accession to the database, insert new data, update or modify present data, and interact with the central system through operations of synchronization. For the Tablet PC an interface was developed which, for each species, displays the specific descriptors and related expressions, to be selected and ticked via touch-screen. Clearly, the Tablet PC can also be used during characterization activities carried out in the laboratory. At the back-end, the operator can also include new accessions in the database, control, update or modify the information entered via Tablet, track the position of the single plants, and monitor the status of characterization of the accessions. The development of the back-end required the creation of an interface on the office PC that allows communication with the Tablet PC and the server. The interface also provides for the possibility to upload photographic documentation or .xls files carrying further information on the specific accessions. In summary, the application of RFID technology in the different processes of characterization of fruit tree accessions and subsequent data management has proven to be a highly efficient tool for genebank and accession management and might well be applied to the management of other crop categories.
An asterisk (*) following a name indicates the presenting author.

Oral Presentations

2:45–3:00 PM

**Gensas v5.0: An Easy-to-use, Web-based Platform for Individual or Collaborative Structural and Functional Genome Annotation and Curation**

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David Neale  
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The Genome Sequence Annotation Server (GenSAS) is a web-based annotation platform that packages multiple command line annotation tools under one, easy-to-use interface. GenSAS walks researchers through each step of the annotation process and provides instructions and hints as each step progresses. These steps include: uploading of genomic sequence(s); uploading of supportive repeat library files, species-specific (or species-related) protein and transcript files; uploading of previous annotations; prediction of gene models with trainable prediction tools; execution of repeat masking tools (including \textit{de novo} repeat identification); execution of structural annotation tools; consensus gene prediction; functional annotation; manual annotation editing; and assistance with organization of files for final publication. The GenSAS is integrated with the popular JBrowse genome browser for feature visualization, and manual curation of structure and function is provided by an integrated Apollo interface. The integrated Apollo also allows for collaborative manual curation, which is ideal for community genome projects. GenSAS was designed with researchers as the target user group and based on feedback, GenSAS is an easy-to-use, customizable, online DNA annotation platform that allows users with little computer science knowledge to create a custom DNA annotation for their sequence(s) of interest for model and non-model organisms.

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3:00–3:15 PM

**Genome Database for Rosaceae: A Resource for Genomics, Genetics and Breeding Research**

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The Genome Database for Rosaceae (GDR, www.rosaceae.org) is the community database for basic, translational and applied research in almond, apple, apricot, blackberry, cherry, peach, pear, raspberry, rose, and strawberry. Built using the Tripal platform, GDR provides an online portal of up to date, curated and integrated genomics, genetics and breeding data, combined with a suite of tools facilitating intuitive data mining and analysis. With a new theme included, GDR has been redesigned to provide more efficient access to the data, tools and resources for crops of interest. New and updated data and functionality in GDR include reference transcriptomes using published RNASeq data, new PlantCyc metabolic pathway databases, syntenic data, the most current genome data, genetic maps, molecular markers, and QTL data. We will also discuss plans for further development through 2019 for this USDA and NSF funded resource.

**Specified Source(s) of Funding:** USDA NIFA NRSP10 and USDA SCRI Awards 2009-51181-06036 and 2014-51181-22376
Volatile Metabolite Changes in ‘Ambrosia’ Apple Fruit Associated with Soft Scald Development

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Soft scald is a postharvest storage disorder that affects some cultivars of apples (Malus domestica) and can cause substantial losses during storage. Delayed cooling treatments following harvest that consist of holding fruit at 20 °C for 4 to 7 days have been shown to be effective in reducing the development of soft scald. However, little is known of the mechanisms underlying the postharvest development of soft scald or its mitigation. Therefore, this study was conducted to explore the impact of delayed cooling on fruit volatile metabolism and its potential relationship with soft scald development. To explore these relationships, ‘Ambrosia’ apple fruit were harvested from three commercial orchards in British Columbia, Canada that historically had issues with the expression of soft scald during storage. Fruit from each orchard were either placed directly into cold storage at 0.5 °C or subjected to a delayed cooling treatment of 20 °C for 4 days prior to cold storage. Expression of soft scald during 3 months of storage was evaluated on 24-apple samples. In addition, headspace volatile compounds were repeatedly sampled from six individual apples from each orchard and treatment after 0, 1, and 3 months of storage using volatile collection tubes. Volatiles were analyzed using gas chromatography-mass spectroscopy on both wax and VF5 analytical columns. Chromatograms were analyzed using an untargeted analysis procedure. Using a hierarchical cluster analysis with group averages based on Euclidian distances, compound groups were identified for each of the analyses. Principle component analysis (PCA) revealed a shift in volatile composition during storage and in response to the delayed cooling treatment. Relationships of fruit volatile metabolism with scald expression and changes in proteins will be discussed.
IAD Values in Relation to Internal Ethylene Concentrations in ‘Delicious’ Apple Fruit Harvested from Trees Treated with Retain and Harvista

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Christopher Watkins*
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The DA meter provides a nondestructive measurement of chlorophyll in fruit using visible/Near Infra Red spectroscopy (vis/NIR) values expressed as the Absorbance Difference index (IAD). Internal ethylene concentrations (IECs) remain the standard for measurement of apple fruit maturity and our studies and that of others show good relationships between IEC and IAD values at harvest, suggesting that the DA meter may be useful for assessing harvest maturity. However, many apple industries use the plant growth regulators (PGRs) Harvista (1-methylcyclopropene; 1-MCP) and ReTain (aminooxyvinylglycine; AVG), inhibitors of ethylene production and perception, respectively, to reduce fruit drop and manage the harvest. The effects of these PGRs on the relationship between IEC and IAD values were studied. Fruit were harvested from ‘Delicious’ trees either untreated or treated with Harvista or ReTain and separated into eight IAD (IAD) value categories in 0.2 unit intervals from 0.2 to 1.8. In untreated fruit, IECs were higher when fruit were more mature (lower IAD values). There were, however, negligible increases in IEC for Harvista and ReTain treated fruit, regardless of maturity. Therefore, DA meter readings in fruit treated with PGRs are not good indicators of harvest maturity. Correlations between IEC, α-farnesene, conjugated trienols (CTols) and superficial scald in cold storage were also investigated.

Specified Source(s) of Funding: 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) and NY Apple Research and Development Program.

Dry Matter and Soluble Solids Concentrations in Apple Cultivars at Harvest and during Storage

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Dry matter concentration (DMC) has been suggested as a new quality metric for apple fruit. In this study, we have investigated the effects of postharvest treatment with 1-methylcyclopropene (1-MCP) and storage type (air and CA) on the relationships between DMC and soluble solids concentrations (SSC). ‘McIntosh’, ‘Honeycrisp’, ‘Red Delicious’, ‘Golden Delicious’, ‘Fuji’, ‘NY1’, ‘Jonagold’, and ‘NY2’ apples were harvested at two harvest dates with one-week intervals, treated with 1-MCP and stored in air for 6 and 12 weeks, or CA for 12 and 24 weeks. The DMC, SSC and other quality factors were measured at harvest and on days 1 and 7 at 20 °C after removal from storage.
The DMC ranged from 112 g·kg⁻¹ to 163 g·kg⁻¹ depending on cultivar. Regression analyses of SSC against DMC resulted in $R^2$ values of 0.744, and these did not increase substantially during storage. The significant increase in $R^2$ values during storage reported by others was not found in our study. Little effect of 1-MCP or storage type was detected. Overall, the results support the concept that SSC is closely associated with fruit DMC, but not that DMC at harvest can be used as a metric to predict SSC of fruit in storage.

Specified Source(s) of Funding: 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) and NY Apple Research and Development Program.

3:00–3:15 PM

Impact of CO₂ on the Energy Status of ‘Honeycrisp’ Apple in Controlled-atmosphere Storage

Diep Tran*
Michigan State University, East Lansing
Randolph Beaudry
Michigan State University, East Lansing

‘Honeycrisp’ fruit is very sensitive to the low O₂ and elevated CO₂ levels found in controlled atmosphere (CA) storage. CA-related injury causes jagged brown lesions and lens-shaped voids in the apple cortex within the first six weeks of storage. We have previously shown that fermentative metabolism was influenced by CA conditions, but the volatiles do not appear to be indicative of CA-related injury per se. The presence of fermentation suggested an inhibition of the apple fruit’s ability to efficiently form energy-related metabolites. We investigated whether adenylate energy charge (AEC) might contribute to cell death in ‘Honeycrisp’. Energy compounds including adenosine triphosphate (ATP), adenosine diphosphate (ADP), and adenosine monophosphate (AMP) were determined in apple tissues by HPLC/UV at 259.1 nm. Samples were lyophilized and 10 kPa CO₂, 3 kPa O₂, 20 kPa CO₂, and 3 kPa O₂ in combination with 3 kPa O₂. After 30 s, the fruits were treated with dimethylamine (DPA) drench (1000 µL·L⁻¹, 30 s) held in 10 kPa CO₂ + 3 kPa O₂ during storage at 3°C. The fruits were sampled at day 0, 3, 7, when reaching half maximal injury and at maximal injury, depending on the treatments. ATP levels in apple tissues decreased during CA storage, especially at 10 kPa and 20 kPa CO₂. The ADP contents in apple tissues were very low at harvest, increased at day 3 and then steadily decreased. The AMP contents did not change much except at 20 kPa CO₂, which increased dramatically during storage time. Adenylate energy charge (AEC) decreased during CA storage except for apple treated with DPA, which maintained above 0.75. We propose that CA conditions might suppress the AEC, leading to cell death and cortex browning in ‘Honeycrisp’ as a symptom of CA injury and that as long as ‘Honeycrisp’ apple is maintained with an AEC above 0.75, it likely remains healthy.
This study demonstrates the potential mechanism of the biological effect of delayed cooling on apple fruit at the proteomic level. It also provides in-depth insight on molecular mechanisms of the delayed cooling treatment in apples.

3:30–3:45 PM

CO₂ Injury in ‘Honeycrisp’ Apple: Dose Response to Diphenylamine

Randolph Beaudry*
Michigan State University, East Lansing

Diep Tran
Michigan State University, East Lansing

‘Honeycrisp’ apple (Malus x domestica Borkh.) fruit are very sensitive to injury by controlled atmosphere (CA) storage, developing brown lesions and lens-shaped cavities in the cortex. The injury is in response to elevated CO₂ and, to a lesser extent, to low O₂. We know from previous work that diphenylamine (DPA) can prevent CA injury to ‘Honeycrisp’ when applied at commercial rates (1000 to 2000 µL·L⁻¹). However, the nature of the dose response of CO₂-related CA injury to DPA is unknown.

To describe this relationship, we stored ‘Honeycrisp’ fruit with CO₂ levels of 0, 5, 10 and 20 kPa in combination with 3 kPa O₂ during storage at 3 °C. Prior to storage, fruit from each treatment were drenched for 30 s with DPA at concentrations of 1, 10, 50, 100, 250 and 1000 µL·L⁻¹. Fruit were assessed for CA injury incidence and severity after 4 months storage. CO₂ injury was evident for all treatments, including 0 kPa CO₂ in the absence of DPA. CO₂ injury declined as the concentration of DPA increased. The concentration of DPA required to completely suppress CO₂ injury was 100, 250, and 1000 µL·L⁻¹ for 0, 5, and 10 kPa CO₂, respectively. Injury for fruit stored in 20% CO₂ declined only slightly at higher DPA levels. The presence of CO₂ injury at 0 kPa CO₂ may be a result of low O₂ in combination with the low amounts of CO₂ that accumulate in the interior of the apple fruit. The results suggest that some protocols for the CA storage of ‘Honeycrisp’ requiring low CO₂ for the first several weeks may not always sufficiently control this disorder if other means to suppress CO₂ injury (e.g., DPA or pre-storage conditioning) are not employed.

Specified Source(s) of Funding: NIFA

Oral Presentations

Oral Session—Teaching Methods

Moderator: Rosanna Freyre
University of Florida, Gainesville

1:45–2:00 PM

Student-initiated Laboratory Projects

Paul Read*
University of Nebraska, Lincoln, NE

Students are often the best source of innovative ideas for learning opportunities, especially for laboratory courses. I have attempted to enhance an understanding of the global impact of fruits from around the world as part of HORT 354, Fruit Crops Laboratory, which I teach at the University of Nebraska. To do this, I have brought tropical and sub-tropical fruits into the classroom for observation, dissection and sampling both the fruit itself and where available, the processed product of such fruits. Several years ago, we were dissecting papaya fruits and one of the students said, “now what do we do with the seeds?” My response was, “what do you want to do with the seeds?” The student responded with a suggested simple germination experiment that focused on the seed’s characteristics, which ultimately resulted in a large number of young papaya seedlings that were left over at the end of the semester. By continuing to grow these seedlings over the winter in the greenhouse, we had 20 large plants that were beginning to flower by the beginning of the following Fall Semester and the offering of HORT 354 again. This provided the opportunity to teach the students through self-discovery about the morphology and flowering characteristics of this tropical crop, including observation of both staminate and pistillate flowers. This also afforded the opportunity to pollinate the flowers and observe and measure the fruits as they develop. I have continued to make this an exercise for students in subsequent years, i.e., start seedlings for next year’s class, while employing the plants produced by the previous year’s class to gain insights into this crop that is not to be found in Nebraska. I have subsequently employed this concept for students to learn about kiwifruit, pomegranates and several citrus species, all as the result of a student’s intellectual curiosity.

2:00 PM – 2:15 PM

Buckeye Badges: A Pilot System Developed at Ohio State University

Tim Rhodus*
Ohio State University, Columbus, OH

The primary objective of the Buckeye Badges Pilot Project is to prove the viability of an alternative credentialing system for curricular achievements. This project in online badging was implemented in two major programs in the department of Horticulture & Crop Science and keyed to competencies and learning objectives established by the department and being used for Undergraduate Program Assessment. Given that approach to academic badging, it will allow easy expansion to additional programs. A total of 607 badges were awarded during the autumn semester with 58 students creating Backpack accounts and accepting 99 badges (16%). During Spring Semester, Buckeye Badges partnered with the campus-wide Denman Undergraduate Research Forum and awarded each presenter a 2016 Denman Forum digital badge. This is a competitive program that requires abstract submissions to be reviewed and approved by a review committee. A total of 526 presenters received their badge award via email. The next phase of the program is to develop a badging model for co-curricular skills that students achieve outside the classroom but are very important to employers as students prepare to enter the work-
Hands-on learning is one of the key components of the horticultural science curriculum. The multifaceted function of institutional teaching gardens and farms in promoting student learning is increasingly recognized. In recent years, we have observed an evident increase of student engagement in active hands-on learning along with the rising enrollment in the major and minor programs as well as in the courses we offer in the Horticultural Sciences Department at the University of Florida. This study was conducted to further identify student perceptions of hands-on learning activities, which mainly take place at the vegetable teaching garden on campus, and their impacts on student learning. A survey instrument using a 1–5 rating scale (1 = highly negative, 2 = slightly negative, 3 = no influence, 4 = slightly positive, and 5 = highly positive) was employed to allow student assess the influence of hands-on activities in class on various aspects of their learning. Students taking any of the four courses related to vegetable crop production during Fall 2015 were contacted by email about this online survey via Qualtrics, and a total of 126 responses were received. Over 90% of the respondents indicated positive impacts of different hands-on activities on acquisition of knowledge in the area relating to the activity, providing them new technical skills in horticulture, devoting their time to be outdoors connecting with nature, and overall motivation in horticulture. Approximately 89% of the respondents reported positive influence of hands-on activities on their interest in the discipline. In addition, more than 75% (less than 90%) of the participants perceived positive effects of class activities in the teaching garden on skills related to team work, interest in guided-research in the horticultural sciences, interest in courses in future semesters that take place directly in the teaching garden focusing primarily on hands-on activities, as well as gaining physical exercise. Interestingly, about 73% of the respondents stated positive impacts of these hands-on activities on inspiration to invent or develop something new or original. Approximately 71% of the respondents also responded positively regarding leadership skills. The positive impacts on writing and presentation skills were less received by students as the no influence response reached about 31%, although approximately 66% of the participants still responded positively. Results from this study provided insights into course and curriculum design and innovation in horticulture for enhancing student engagement and recruitment.
Hands-on Horticulture: A Magnet Course for the Horticulture Minor
Marvin Pritts*
Cornell University, Ithaca, NY

Hands-on Horticulture was conceived as a course to entice students from across the university into sampling the wonderful world of plants and, subsequently, take additional horticulture and plant science courses. The course is offered once a week in a four-hour block during the spring semester. Each week students are introduced to a new horticultural topic, such as floral design, plant propagation, bulbs, natural dyes, pruning, art, season extension techniques, pest management, garden design, grass, and water gardening. Students are provided with an overview and introduction of the topic, and then learn to perform the task or skill related to the topic. Guests are occasionally used who have expertise on a specific topic and can guide the students through their task. Incorporated into each class is a culinary experience where students are invited to consume a food product related to the topic at hand, with the goal of providing a food that they have never consumed before. The course culminates with a Saturday field trip to visit horticulture professor’s gardens. Learning is assessed through weekly quizzes, reflection papers, a photo project, and a final project. Hands-On Horticulture is very popular with students, and even though it is offered on Friday afternoons, the course fills to capacity quickly. Limits had to be placed so that seniors and plant science majors cannot pre-enroll. This course not only has motivated students to take additional horticulture courses or minor in horticulture, but it has provided a strong pool of summer interns and student researchers for horticulture faculty. Although the course expense per student is higher than average, the campus-wide exposure that this course receives makes it worth the investment.

Greenhouse Online Training at the University of Florida IFAS Extension
Rosanna Freyre*
University of Florida, Gainesville, FL

A new Greenhouse Training Online program was initiated in 2015 at the University of Florida. The objective was to deliver multilingual professional development training on horticultural science for greenhouse growers, from the United States and developing countries, many of whom have limited access to formal training in horticulture. Three courses related to greenhouse and nutrient management were delivered in English and Spanish using an eLearning platform during 2015, where each course consisted of eight pre-recorded lessons and associated assignments over four weeks. Interactive feedback was provided via email or chat sessions, with a final course evaluation survey. A total of 444 students enrolled and 363 graduated (82%). Participants included 67 (19%) international, and 57 (16%) took lessons in Spanish. We conducted end-of-class surveys for three of the four classes. Results indicated that 50% to 56% of the participants were growers and 57% to 88% in the United States, representing 31–47 companies or organizations. In all classes, students ranged from having no experience in greenhouses or nurseries, to having more than 10 years in the business. A total of 38% to 53% indicated that their highest level of education or training in horticulture was either learned on the job, or in high school. For Greenhouse 101, students rating their knowledge of plant science for greenhouse production as either very good or expert before and after taking the course, increased from 30% to 81%. For Nutrient Management 1 and Nutrient Management 2, students rating their knowledge of plant nutrition as either very good or expert before and after taking the course, increased from 23% to 76%, and from 30% to 77%. These three courses will be taught again in from May to November 2016, with the addition of new courses in Plant Diseases and Weed Management.

Developing Critical-thinking Skills in a Landscape Horticulture Class
Tim Smalley*
University of Georgia, Athens, GA

I redesigned a landscape horticulture class to provide students more exercises to develop problem-solving and critical-thinking skills so students would be better prepared to make science-based decisions. These changes were implemented while limiting the reduction in exposure to technical skills that students value. Pruning, planting, and soil testing lab exercises were redesigned to expose students to proper experimental design. More research tables were presented and discussed in class for interpretation and development of recommendations so students could better understand the origin of science-based decisions. Each student wrote a research paper on a horticultural issue and chose a pertinent research table to present in class to stimulate class discussion and class formulation of a recommendation. Surveys conducted in 2012 and 2014 indicate that the course was effective in increasing the student’s knowledge of the scientific process and technical expertise.

Horticultural Education of Indigenous Students
Roland Ebel*
Universidad Autónoma del Estado de México, Toluca, Mexico

Despite the heterogeneity of American indigenous communities and a tremendous variety of educational, regional and individual backgrounds, there are remarkable common patterns regarding higher education of indigenous students, which predominantly characterize them as highly appropriate for succeeding in horticultural careers. Globally, education of indigenous youngsters has become a growing concern and resulted in manifold strate-
Oral Presentations

2:00–2:15 PM

ers in the Americas and that we can learn a lot from each other. We should not forget that indigenous peoples were the first agricultural teachers to process virtual information, many (largely rural) indigenous undergraduates bring a profound understanding of ecological interactions or even a practical horticultural experience to the classroom. Especially in Latin America, natives involve from an early age in agricultural activities, which is why they show impressive creativity regarding the application of their knowledge in the field. Besides their consequential social skills, their observation abilities and talent to extemporize practical solutions, indigenous undergraduates are also widely respected as dedicated students (frequently outgoing their non-native peers). Contrariwise, indigenous students all over the Americas suffer from poorer schooling than their non-native colleagues; they also tend to struggle with the processing of auditory information. Due to their cultural background and/or experience with racial discrimination, indigenous undergraduates may appear silent, timid, and reserved to their teachers. Finally, there might be linguistic restrictions: even if they speak the educational language fluently, some students tend to misinterpret certain concepts. Therefore, language integration plays an important role in indigenous education. It requires the faculty to get familiar with the richness of indigenous concepts regarding organisms, soils, weather, and crop management. Likewise, teaching in an intercultural environment demands teachers to learn about the cultural and ethnic background of their students, so they can offer space for observation and understand that their potential reservation is not necessarily a sign of disinterest. Given the virtues of indigenous students, experiential education, where the imparted content in the classroom is linked with its application outdoors, is indispensable for succeeding in this milieu. We should not forget that indigenous peoples were the first agricultural teachers in the Americas and that we can learn a lot from each other.

Oral Session—Human Issues in Horticulture

Moderator: Lucy Bradley
North Carolina State University, Raleigh, NC

2:00–2:15 PM

The National Initiative for Consumer Horticulture—A Strategic Plan

Lucy Bradley*
North Carolina State University, Raleigh, NC

Thomas Bewick
USDA-NIFA, Washington, DC

Ellen Bauske
University of Georgia, Griffin, GA

Mary Hockenberry Meyer
University of Minnesota, Chaska, MN

Richard Durham
University of Kentucky, Lexington, KY

Gail Langellotto
Oregon State University, Corvallis, OR

Natalie Bumgarner
University of Tennessee, Knoxville, TN

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

Sheri Dorn
University of Georgia, Griffin, GA

Despite the existence of many effective local, state and regional consumer horticulture programs no national organization or vision links efforts across the United States. As a result there has been limited success in securing federal funding and national sponsors. With representatives from universities, public gardens, nurseries, garden related businesses, federal government and gardeners, the National Initiative for Consumer Horticulture (NICH) has been created to develop a national strategic plan for Consumer Horticulture. Facilitated by the United States Department of Agriculture National Program Leader for Horticulture, a twelve member Steering Committee drafted a mission, vision, core values, goals, and objectives for the initiative. A national workshop was then hosted to solicit wider input in developing specific strategies to achieve each objective and to examine various options for structure and leadership. The recommendations from workshop participants were synthesized and then distributed via the NICH website and listserv as a survey for all interested parties to participate in selecting the components that best represented their interests. Next steps include finalizing the strategic plan, selecting an organizational structure, and selecting leadership.

2:15–2:30 PM

The Urban Food Systems Symposium: A Professional Meeting to Change the Way We Think about Global Food Security

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

Kimberly Oxley
Kansas State University, Olathe, KS

Cary L. Rivard
Kansas State University, Olathe, KS

Judy Favor
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Sara E. Gragg
Kansas State University, Olathe, KS

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

HortScience 51(9) Supplement—2016 ASHS Annual Conference
To meet the challenge of feeding the predicted world population of 9 billion in 2050 and beyond, the identification of sustainable and alternative food production practices that continue to meet, or exceed, high expectations for quality and safety is essential. Robust systems must be built in order to maintain food security for growing urban populations, in particular. Kansas State University’s (KSU) agricultural heritage, food systems expertise and world-class research facilities firmly establish the university as a leader in addressing the growing technological, educational and human resource needs of the global food system. In April 2015, a group of research and extension faculty at KSU were awarded a grant to host the first Urban Food Systems Symposium in the United States. The symposium is a collaboration with a local not-for-profit organization, Cultivate Kansas City. Funding that was provided by the KSU Global Food Systems Initiative was leveraged to gain sponsorship from various agencies including: the University of Missouri, Kansas Sustainable Agriculture Research and Education (SARE) program, and the City of Kansas City, MO, in addition to industry partners. Internal sponsors also included the Department of Horticulture, Forestry, and Recreation Resources as well as the Food Science Institute. Planning began in April 2015 and seven committees were formed, including: organizing, sponsorship, scientific, marketing and promotion, facilities and logistics, conference tour(s), and evaluation committee. Efforts were immediately put into place by the marketing committee, including the development of a website, printed materials, social media accounts, online advertising, and email marketing efforts. The professional networks of the organizing committee members played an essential part in the marketing efforts. Additionally, a national contacts database was built by the Urban Food Systems graduate students. The email marketing list has grown to over 650 email addresses and the website traffic averaged nearly 100 visits per month as of March 2016. Abstract submission information was marketed throughout related Urban Food Systems associations, news outlets, social media, website and email marketing efforts. A total of 91 abstracts were received including submissions from the United States, Denmark, and Nigeria. Nine student travel grants were awarded out of 23 submissions received. The abstracts include information related to an interdisciplinary group of topics. The goal of the Urban Food Systems Symposium is to develop a community of researchers, educators, and community leaders to define and develop this important and emerging discipline.

Specified Source(s) of Funding: Kansas State University Global Food Systems Initiative

An asterisk (*) following a name indicates the presenting author.
2012 to 2015, University of California Cooperative Extension (UCCE) conducted an outreach program to raise awareness of local produce and increase sales of local fruits and vegetables. We conducted tastings, cooking classes, and other community outreach events, providing nutrition and produce information and samples of fresh, local produce. We also conducted consumer and farmer surveys. This paper focuses on the survey component of the project; the assessment of consumer attitudes toward locally produced food and constraints to buying local. These surveys provide insights into marketing and motivations for purchasing local food. We collected price data from local outlets where produce is sold, as price was an oft-cited reason for not buying local produce. We also collected sales data from farmers’ market vendors to gauge the impact of outreach and tastings on local produce sales. Consumer survey results show the value of tasting and providing recipes to help introduce new produce or new ways to use familiar produce. Both consumer and farmer surveys show the impact of outreach and tastings on farmers’ market traffic, produce sales, and consumption. Survey results clearly delineate a community definition of what is local; characterize the purchasing habits of farmers’ market shoppers in a variety of locations; and indicate critical barriers to increasing consumption of locally grown produce.

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

3:00–3:15 PM

**Partnerships Transform a Vacant, Urban Lot into Food Production Hub**

Kelly Young*
University of Arizona, Phoenix, AZ

Katie Poirier
City of Phoenix, Phoenix, AZ

Partnerships are fundamental in improving local food systems. The City of Phoenix, the University of Arizona Cooperative Extension, the International Rescue Committee (IRC), local schools and other non-governmental agencies have partnered to grow food on a 15-acre parcel on vacant land near the busiest intersection in the nation’s 6th largest city. A vision of City of Phoenix Mayor Greg Stanton, the project titled Phoenix Renews was launched in 2012 and has become a focal point for activity and discussion around land and water access for food producers, supplying the demand for locally-grown food, community engagement, environmental education, and local food policy. The City of Phoenix offers subscription-based community garden plots for home gardeners and organizes community volunteerism opportunities that actively engage residents in food production for local consumption. The University of Arizona Cooperative Extension offers beginning farmers tools and technical support at the site on a 1-acre incubator farm. The IRC New Roots Program farms 4 acres on the site to supply their CSA and other local markets. The City of Phoenix offers the land and irrigation water free of charge to partner organizations and encourages cooperation among them to support a more vibrant local food system.

Specified Source(s) of Funding: USDA Specialty Crops Block Grant (Louisiana Department of Agriculture and Forestry)

3:30–3:45 PM

**The Effect of Horticultural Community Service Activities on Incidence of Recidivism in Offenders**

Tina Waliczek*
Texas State University, San Marcos, TX

Megan Holmes
Texas State University, San Marcos, TX

The average cost of housing a single inmate in the United States is roughly $31,286 a year, bringing the total average cost states spend on corrections to an average of more than $50 billion a year. Statistics show 1 in every 34 adults in the United States is under some form of correctional supervision; and after 3 years, more than 4 in 10 prisoners return to custody. The purpose of this study is to determine the differences in numbers in incidences of recurrences of offenses/recidivism of offenders completing community service in horticultural versus non-horticultural settings. Data were collected by ob-
taining offender-profile probation-revocation reports, agency records, and community-service supervision reports from the Hays County Probation Office in San Marcos, TX. This sample includes both violent and non-violent offenders classified as: A, B, and C misdemeanors, a capital felony, first, second, and third degree felonies, and a state felony and was evaluated for trends. The results and information gathered support the continued notion that horticultural activities can play an important role in influencing an offender’s successful reentry into society.

Oral Session—Ornamentals/Landscape and Turf 1
Moderator: Chris Martin
Arizona State University, Mesa, AZ

2:00–2:15 PM
Cut Less-Growth Control of Five Landscape Shrubs By Flurprimidol and Irrigation
Yan Chen*
Louisiana State University Ag Center, Hammond, LA
Allen Owings
Louisiana State University Ag Center, Hammond, LA

Shrubs used as hedges in urban landscapes require frequent trimming to maintain desired size and shape, which has become a top cost contributor to landscape service companies due to labor cost for trimming and cleaning and equipment wear. Cutless.33G is a granular formulation of the plant growth regulator flurprimidol and has provided relatively longer residual effect on woody ornamentals in a previous study. The objective of the present study was to evaluate how the effects of this granular product may be affected by irrigation method. Cutless.33G at 0, 14, or 21 lb/1000 ft² and three irrigation methods: microsprinkler, drip irrigation, or no-irrigation, were evaluated for their effects on the growth and quality of Burford holly, Elaeagnus, Ligustrum, sweet viburnum, and wax myrtle from 2013 to 2015. Plant growth responses to Cutless were species specific. Wax myrtle was the most responsive with 31% size reduction at 21 lb/1000 ft² compared with the untreated at 8 weeks after treatment. Compared with drip and no-irrigation, overhead microsprinkler resulted in smaller plants in Elaeagnus and wax myrtle across Cutless rates. However, this effect was affected by rainfall amount and inconsistent among years. Elaeagnus and sweet viburnum had no or inconsistent response to either Cutless or irrigation. However, time spent for trimming the hedges treated with Cutless and resulting clipping amounts were significantly less than those of the untreated to maintain the same hedge height and width. Overall, irrigation is important for effective delivery of this PGR to the plant and its benefit in growth regulation was significant in reducing time spent in trimming, cleaning, and potentially equipment wear.

Effects of Plant Growth Regulators Ethephon and Protone on Flowering of Bougainvillea xbuttiana ‘Afterglow’
Mun Wye Chng*
University of Florida/IFAS, Davie, FL

Bougainvillea cultivars are widely used ornamentals valued for their ability to bloom profusely while tolerating poor growing conditions such as pollution, compaction, and drought stress. Bougainvillea xbuttiana are mostly considered qualitative short-day plants that flower more readily and profusely under short day lengths. Water stress has been shown to partially substitute for short-day induction. Ethylene and abscisic acid (ABA) are two drought-stress-related plant hormones that may have an important role to plant in drought-stress-induced flowering in Bougainvillea. The plant growth regulators Ethephon (2-Chloroethylphosphonic acid) and ProTone® (s-ABA) were applied to B. xbuttiana ‘Afterglow’ to investigate the effects of exogenous applications of ethylene and ABA on the flowering response of this cultivar, under 14-h photoperiod. Both Ethephon and ProTone® applied as a “sprech” at 75 ppm concentration did not result in significant increase in flowering. However, Ethephon treatment corresponded with a slight increase in flowering, while ProTone® treatment did not. ProTone® treatment appeared to cancel out the effect of Ethephon when applied simultaneously at 75 ppm concentration. Further research into relationship between ethylene and ABA in flowering response of Bougainvillea, as well as the application rates of ethylene and ABA growth regulators, is warranted.

Mulch and Root-ball Manipulation Affect Establishment of Container-grown London Planetrees
Bert Cregg*
Michigan State University, East Lansing, MI
Dana Ellison
Michigan State University, East Lansing, MI

Landscape contractors and urban foresters are increasingly using container-grown shade trees for tree planting projects. Establishment of container-grown trees, however, may present unique challenges compared to traditional balled-in-burlap trees. In this project we conducted two experiments to examine growth and physiological responses of London planetrees (Platanus x acerifolia ‘Bloodgood’) following transplanting. In the first experiment we planted 48 planetrees, from #25 containers, in 3 x 2 factorial combination of root-ball manipulation (‘control’ = no treatment; ‘shaved’ = outer 3 cm of roots removed; or ‘teased’ = outer circling roots teased apart) and fertilization (no fertilizer or 400 g of controlled release fertilizer [15–9–12 (N–P2O5–K2O), 5–6 mo. release]). In the second experiment 48 planetrees from #25 containers were planted...
in a 3 x 2 factorial of root-ball manipulation and mulch (no mulch or 8 cm of ground pine park mulch). Fertilization did not increase height or caliper growth after two years ($P > 0.05$) but increased ($P < 0.05$) leaf SPAD chlorophyll index. Both root-ball treatments increased new root growth relative to the control. Shaving the root-ball increased new root growth by 67% compared to the control trees; whereas teasing apart the root-ball increased new root growth by 49% relative to control. Mulching consistently increased soil moisture at 0–15 cm and 0–45 cm depth and increased tree caliper and height growth. The results indicate that root-ball manipulation at planting can enhance new root growth. Mulching greatly improved soil moisture availability and growth after transplanting, whereas fertilization had only a modest impact on post-transplanting tree performance.

**Specified Source(s) of Funding:** MSU AgBioResearch, Project GREEEN, J. Frank Schmidt Family Charitable Foundation

2:45–3:00 PM

**Determining Minimum Irrigation Coefficients for Landscape Trees Based on Evapotranspiration and Public Opinion**

Richard Beeson*

University of Florida, Apopka, FL

The objective was to determine the minimum amount of water required to maintain aesthetically pleasing landscape trees. Beginning in 2009, 63 trees produced in 27-L containers were transplanted into a sand soil under a double polyethylene covered, open-side gutter-connected greenhouse in Apopka, FL. The first species were *Quercus virginiana*, and *Ulmus parvifolia*. Trees were transplanted in late August with abundant irrigation and allowed 6 months for root establishment. In late February the following year, irrigation volumes were estimated based average on trunk cross-sectional measured 30 cm above ground level, using models previously determined for each species derived from 5 to 6 years of weighing lysimeter data and daily ETo. Irrigation was based on ETo measured inside the structure and at 3 reduced percentages below 100%, to 55%. Daily ETo. Irrigation was based on ETo measured inside the greenhouse. This was repeated in 2010 with *Magnolia grandiflora* and *Acer rubrum*; and in 2011 with *Pinus elliottii* and *Ilex opaca* ‘East Palatka’ species. Most species were rated aesthetically acceptable at irrigation rates of 55% of ETo. However shoot growth was greatly reduced. *Acer rubrum* trees all died.

**Specified Source(s) of Funding:** Southwest Florida Water Management District

3:00–3:15 PM

**The Relationship of Four Substrates to Nitrogen and Phosphorus Removal and Biomass Establishment in a Greenhouse Natural Swimming Pool Experiment**

Margaret Hoffman*

Pennsylvania State University, University Park, PA

Natural swimming pools, (NSPs) are constructed bodies of water, with an impermeable liner between the soil and water, a designed hydraulic and skimmer system and a complex ecological community as a filter. The NSPs rely on biological filtration, the interaction of a balanced system including bog vegetation, bacteria and substrate to reduce nitrogen (N) and phosphorus (P) levels in the NSPs water column to less than 30 mg·L⁻¹ NO₃-N, and 0.01 mg·L⁻¹ P. These are the levels recommended by the 2007 German FLL Guidelines for NSP Design and Operation. While many studies have quantified the nutrient removal mechanisms of treatment wetlands and stormwater bioretention systems, no studies have quantified the nutrient removal capabilities of substrates and vegetation in the low nutrient environment of an NSP designed as a landscape amenity. In this study, a mass balance analysis of vegetated NSP greenhouse mesocosms estimated phosphorus and nitrogen inputs, outputs and storage for substrate treatments of 1) haydite/clay, 2) norlite, 3) growstone, and 4) river gravel. All treatments contained *Saururus cernus*, lizard’s tail, and *Iris versicolor*, blue flag iris, and all aboveground biomass was harvested, weighed and analyzed for P and N after 15 weeks. System outputs consisted of nutrients contained in harvested biomass while root biomass and substrate were considered nutrient storage compartments. The haydite/clay substrate treatment was the only substrate able to reduce phosphorus levels of the mesocosm water to 0.01 mg·L⁻¹. Plant direct uptake proved insufficient to remove all nutrient inputs, and substrate type was statistically significant in nutrient storage. All substrate treatments reduced mesocosm water NO₃ to the target levels of 30 mg·L⁻¹. Iris produced significantly higher biomass than the lizards tail, and plant biomass was positively correlated with NO₃ removal. Two substrates demonstrated potential as substrate for bogs in natural swimming pools. Norlith and haydite/clay reduced NO₃ nutrients to 26.01 and 5.83 mg·L⁻¹, and 0.02 and 0.01 mg·L⁻¹ for P, respectively. It seems probable that the addition of calcined clay to norlith might also improve P removal from the 0.02 mg·L⁻¹ measured result to the recommended level of 0.01 mg·L⁻¹.

3:15–3:30 PM

**Effect of Tree Species and Shade Structures on Outdoor Human Thermal Comfort**

Kaylee Colter

Arizona State University, Mesa, AZ

Chris Martin*

Arizona State University, Mesa, AZ

The objective of this research was to evaluate overhead shade
An asterisk (*) following a name indicates the presenting author.

**Oral Presentations**

Diversity of Bees Across Different Urban Lawn Types in Lubbock, Texas

Alicia Patridge*
Texas Tech University, Lubbock, TX

Bees are an important aspect of landscapes. Without them the pollination of many vital food crops would not occur, leading to food shortages. As urbanization has increased around the world, bee populations have decreased as their natural habitats have been destroyed. Within urbanized areas there are urban gardens that can be used to sustain bee life and even allow it to thrive abundantly. For the southern high plains, water has been an important dilemma. Due to the water shortage problem, many residents have shifted to more water efficient yards and gardens, in order to conserve water. This study is focused on finding what yard types and characteristics within an urban setting on the southern high plains attract the greatest diversity of bees. Gardens around Lubbock, TX, were selected based on the maintenance level: low (xeriscaped and unmanaged), medium (turf dominant) and high (flowering dominant). Low maintenance refers to drought tolerant plants or minimal yard upkeep and high maintenance meaning heavily irrigated and difficult upkeep. Yard sizes were determined and garden zones were created based on similar plant material within the landscape. Each of the plants in the landscape was then identified and tree DBH was measured. After this assessment, bees were then collected using yellow bee bowls and sweep netting. The bees have been identified to the family level and the numbers and types of different morphspecies within each family have been accounted for. Landscapes with higher maintenance levels and a greater number of flowering plants had the most abundance and diversity of bees collected. As for bee families, Halictidae bees were most abundant across all landscape types.

**Oral Session—Citrus Crops**

Moderator: Manjul Dutt
University of Florida, Lake Alfred, FL

2:30–2:45 PM

Maturation and Ripening of ‘Midknight’ Valencia Sweet Orange Fruit: Dynamics in Ethylene Production, Respiration Rate, and Quality Parameters

Muneer Rehman*
Curtin University, Perth, Australia

Zora Singh
Curtin University of Technology, Perth, Australia

Tahir Khurshid
Agriculture NSW, Dareton, Australia

‘Midknight’ Valencia is a late maturing cultivar of sweet orange (*Citrus sinensis* L. Osbeck) that is harvested in Western Australia during October to mid-December. Changes in ethylene production, respiration rate, and quality parameters viz. fruit colour, juice percentage, SSC:TA ratio, individual sugars, vitamin C, and total antioxidants during fruit maturation and ripening [314 to 389 days after fruit set, (DAFS)] at 15-day intervals were investigated. Thirty fruit were randomly sampled in each replication from five trees (nine-year-old), grown on Carrizo citrange rootstock, spaced at 7.5 m x 2.7 m, with north–south row orientation at Moora (latitude 31°21’ South, longitude 155°55’ East), Western Australia. The experimental design was completely randomised design with four replications. Ethylene production was significantly higher (2.5 and 2.6 pmol·kg\(^{-1}·s\)^{-1}) in both 314 and 389 DAFS as compared to all other sampling times. Respiration rate was increased from (0.1 to 0.2 μmol·kg\(^{-1}·s\)^{-1}) from 314 to 344 DAFS and decreased from 359 to 374 DAFS and was significantly highest (0.3 μmol·kg\(^{-1}·s\)^{-1}) on 389 DAFS. Citrus color index (CCI) of the fruit was significantly higher (6.9 and 7.1) on 314 and 329 DAFS and declined to minimum (5.4) on 389 DAFS due to re-greening of the rind. The concentration of glucose (11.5 g·L\(^{-1}\)) and fructose (20.1 g·L\(^{-1}\)) in the juice were found higher on 374 DAFS, while sucrose (45.2 g·L\(^{-1}\)) and total sugars (73.6 g·L\(^{-1}\)) was found maximum on 329 DAFS. The highest level of vitamin C in the juice was (429.40 mg·L\(^{-1}\)) on 344 DAFS. Total antioxidants declined in the juice from 314–359 DAFS followed by an increase from 374–389 DAFS. Juice percentage increased (40% to 54%) from 359 to 389 DAFS and SSC: TA ratio steadily increased with the advance of fruit maturation and ripening from 314 to 389 DAFS.
DAFS will be beneficial for juice industry due to higher SSC: TA ratio and per cent juice but lower CCI due to slight re-greening of fruit under Western Australian conditions.

Specified Source(s) of Funding: Australian Centre of International Agricultural Research (ACIAR)

2:45–3:00 PM

Hybridization Studies Between the Australian Finger Lime and Conventional Citrus Cultivars for Germplasm Enhancement and New Cultivar Development

Manjul Dutt*
University of Florida, Lake Alfred, FL
Qibin Yu
University of Florida, Lake Alfred, FL
Fred Gmitter
University of Florida, Lake Alfred, FL
Jude Grosser
University of Florida, Lake Alfred, FL

The finger lime (Microcitrus australasica) is native to Australia and is a thorny understory shrub producing finger-shaped fruit that contain compressed juice vesicles which tend to burst out when cut. These tart lime flavored juice vesicles have been termed as “citrus caviar” and are gaining popularity in restaurants as a garnish and as a component in mixed drinks. In addition, preliminary studies indicate finger limes to be tolerant to HLB. These cultivars can potentially be used as a source of HLB resistance and play a role in HLB management. We are creating new genetic combinations by hybridizing microcitrus with conventional citrus—using both conventional and somatic cell fusion techniques. A large population of diploid, triploid and tetraploid hybrids have been produced and their hybrid status confirmed using Random Amplified Polymorphic DNA (RAPD) and fluorescently labeled expressed sequence tag simple sequence repeat (EST-SSR) molecular markers. This germplasm will be screened for HLB tolerance and selected lines will be propagated for field trials. Field trials will also evaluate traits including plant growth and fruit/juice vesicle characteristics. Results from our research should generate useful hybrids that could be commercially cultivated as a niche specialty crop and also contribute to future citrus improvement and HLB tolerant cultivar development.

3:00–3:15 PM

Whole Plant Destructive Screening for Huanglongbing Susceptibility with Conetainer Seedlings Exposed to No-choice Asian Citrus Psyllid Inoculation

Ed Stover*
USDA-ARS, Ft Pierce, FL

Huanglongbing (HLB) is associated with Candidatus Liberibacter asiaticus (Las) and is vectored by the Asian Citrus Psyllid (ACP, Diaphorina citri). HLB is devastating the Florida citrus industry, with production reduced by 60% in the last 12 years, and HLB is considered the greatest threat to citrus production worldwide. HLB-resistant plants are likely the best solution to this problem, but screening for resistance is slow, typically requiring 10–12 months following inoculation. In this study we used no-choice ACP inoculation (two-week infestation of 15 ACP per plant from a Las+ colony) of small seedling trees in conetainers, and destructively sampled 10 trees of each genotype at 3, 6, and 12 weeks after inoculation. At sampling, the trees were: 1) divided into leaves, stems and roots; 2) fresh weight of each tissue was determined; 3) tissues were ground in liquid nitrogen; 4) 200 mg of each tissue was sampled and DNA extracted; 5) qPCR was run to quantify Las using the LasLong probe/primer set; and 6) total Las load was calculated in each tissue type. Kruskal-Wallis statistical analyses were used to assess the data in two ways, either samples having non-detectable Las were designated as having 2 Las per sample (Ct = 40) or these samples were excluded from analysis. Only a few differences in interpretation resulted. Percentage of samples (tissue in each genotype) with detectable Las ranged from 10% to 100% at week 3 (mean 52%), 40% to 83% in week 6 (mean 62%), and 40% to 90% in week 12 (mean 63%). Across all samples: 1) Las per plant was 5 billion in week 3, 10 billion in week 6, and 45 billion in week 12; 2) both Las/plant and Las titer were significantly greater at week 12 compared to week 3; 3) there was no or little difference in Las/plant or Ct between tissue types; and 4) HLB-susceptible Citrus sinensis was clearly distinguished from HLB-resistant Poncirus trifoliata with higher titers and 35x the Las/plant. Comparing each genotype/tissue/timepoint:

1) only leaves showed a statistically significant increase in Las/plant and Ct over time, in all except Poncirus trifoliata which displayed a similar trend; and 2) by week 12 after inoculation, HLB-susceptible Citrus sinensis was clearly distinguished in all analyses from HLB-resistant Poncirus trifoliata and in most comparisons against their hybrid Carrizo, but only in roots. Based on these results, genotype comparisons in susceptibility to Las can be expedited by sampling roots for Las at 12 weeks after conetainer tree inoculation.

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

3:15–3:30 PM

Strigolactones Induced Vegetative and Reproductive Growth in HLB-infected Plants

Naveen Kumar*
University of Maryland Eastern Shore, Salisbury, MD
Ed Etxeberria
University of Florida, Lake Alfred, FL

Strigolactones (SL) are carotenoids derived novel plant hormone with multiple physiological and anatomical functions. Two-year-old greenhouse grown HLB-infected and healthy control Sweet orange ‘Valencia’ (Citrus sinensis L. Osbeck) trees were used for this study. Tress were sprayed at an interval of three months
with 10 μM SL. Trees were grouped in four categories based on SL treatment: SL treated HLB-infected trees, HLB-infected trees, SL treated healthy trees, and healthy control trees. Similar experiment was also conducted in citrus grove at CREC, Lake Alfred, FL, with 10 trees each for above-mentioned four treatments. Healthy control trees were sprayed in a commercial grove at Marion County, FL. SL spray applications in greenhouse conditions resulted in early induction of spring and summer flush and early flowering in HLB-infected trees in comparison to control and HLB-infected non-sprayed trees. The number of new vegetative branches is more in SL treated HLB trees in comparison to other treatments. Fruit peduncle diameter and fruit diameter was greater in SL treatments. Flower retention, fruit drop, and various anatomical parameters were also evaluated.

Differential Rootstock-mediated Scion Gene Expression in HLB-susceptible versus Putatively HLB-tolerant Scion/Rootstock Combinations

Aditi Satpute*
University of Florida/IFAS-Citrus REC, Lake Alfred, FL
Matias Kirst
University of Florida/IFAS, Gainesville, FL
Fred Gmitter
University of Florida, Lake Alfred, FL
Christine Chase
University of Florida, Gainesville, FL
Jude Grosser
University of Florida, Lake Alfred, FL

Rootstocks are an invaluable part of citrus production. Citrus trees are commercially grown by grafting or budding scions onto rootstocks. Many scion traits, such as disease resistance, plant vigor, fruit size, and precocity, are influenced by rootstocks. Thus, rootstock genotype is important in determining scion quality. Florida citrus production is consistently declining because of the presence of Huanglongbing (HLB) disease. There is a need for HLB tolerant or resistant rootstocks in Florida to achieve sustainable fruit production and to maintain plant health. The University of Florida Citrus Breeding Program has developed rootstocks that have shown potential to reduce HLB disease severity and infection frequency based on field performance and visual symptom observations. In the present study, high throughput RNA sequencing technology was used to quantify leaf gene expression levels in ‘Valencia’ sweet orange [Citrus sinensis (L.) Osbeck.] scions, and to identify the rootstock-mediated gene expression patterns comparing the industry standard ‘Swingle’ citrumelo [Citrus paradisi MacFaden × Poncirus trifoliata (L.)] rootstock with selected newly developed, putatively HLB-tolerant rootstocks that visually reduce HLB severity. The results showed that significant differentially expressed genes belonged to the following gene function categories: defense induction, protein kinases, transportation, cell homeostasis, transcription factors and hormonal regulations. Based on phenotypic evaluation, we estimate that photosynthesis is upregulated in scions grafted on newly developed, putatively HLB-tolerant rootstocks. The juice analysis of fruit harvested from ‘Valencia’ grafted on new rootstocks had a higher Brix:acid ratio (maximum 15) compared to the fruit harvested from ‘Valencia’ grafted on ‘Swingle’. Our findings support previous research that suggests rootstocks can differentially reprogram the scion transcriptome under biotic and abiotic pressure.

Oral Session—Nursery Crops 1

Moderator: Jeb Fields
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Best Management Practice Use and Efficacy for Virginia Nurseries and Greenhouses

Rachel Mack*
Virginia Polytechnic Institute & State University, Virginia Beach, VA
Jim Owen
Virginia Polytechnic Institute & State University, Virginia Beach, VA
Alexander Niemiera
Virginia Polytechnic Institute & State University, Blacksburg, VA

Virginia’s nursery and floriculture industries account for an estimated $213M in yearly sales and are major economic contributors to the estimated $1.42B of ornamental crops sold in the Mid-Atlantic U.S., including the Chesapeake Bay Watershed states. Crop production efficiency and environmental stewardship are increased through best management practices (BMPs). However, there is a lack of evidence defining which BMPs are most employed and most effective by ornamental crop producers, and scientific data backing the use of these BMPs have not been synthesized for usable analysis. Objectives of the study included 1) identifying the most utilized BMPs by Virginia nursery and greenhouse crop growers, and 2) determining the reasons for the use of these BMPs. A BMP survey was disseminated to approximately 350 Virginia nursery and greenhouse growers and managers via three methods: in-person interviews at the Mid-Atlantic Nursery Trade Show (Baltimore, MD), email, or an online Qualtrics survey software tool. Seventeen percent (60 surveys) of respondents completed the 22-question, Institutional Review Board-approved survey. The objective of the questionnaire was to identify BMPs being utilized, along with their strengths, weaknesses, and risks of implementation. The survey also queried participants on BMP utilization for the management of agrichemicals, irrigation, fertilizer, and non-point source runoff. Survey results indicated the most utilized BMPs included: irrigation based on plant need for water, optimized irrigation efficiency, and grouping plants by water needs. Most frequently cited reasons for utilizing BMPs for irrigation management, fertilizer management and runoff management were:

An asterisk (*) following a name indicates the presenting author.
saves water or other resources, saves money, and environmental stewardship, respectively. Environmental stewardship ranked in the top three out of eight choices demonstrating that concerns for environmental stewardship are a significant factor for grower BMP use in all categories. This research aids scientists and growers a better understanding of which BMPs have been most readily utilized, and delineates producer’s motivation for BMP implementation. Empowering growers with such information permits them to make decisions that are both economically and environmentally sound when deciding on BMP adoption. This research increases the information available for growers in complying with environmental regulations in protected areas like the Chesapeake.

Specified Source(s) of Funding: Funded in part by the Virginia Nursery Landscape Association, Virginia Agricultural Council, and Virginia Agricultural Experiment Station and the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

4:15–4:30 PM

**Counting Costs: Modeling Operational Water Treatment Technologies to Help Ornamental Growers Understand the Costs and Benefits of Recycling Irrigation Water**

John Majsztrik
Clemson University, Pendleton, SC

Daniel Hitchcock
Clemson University, Georgetown, SC

Saurav Kumar
Virginia Polytechnic Institute & State University, Manassas, VA

David Sample
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Sarah White
Clemson University, Clemson, SC

What drives growers to make changes at their operation? Saving time or money is most important for some, while for others it could be reducing environmental impacts or improving consumer perceptions. Helping nursery producers understand current practices and modify them with research-based information is critical to addressing this question. Models can help growers address questions specific to their operation, and can demonstrate the impact of current practices and predict the impact of changes in terms of cost, labor, environmental benefits etc. A disinfection model is the first in a series of models being developed to simulate what happens when irrigation water is recycled. The model series will incorporate research data and operation-specific information to inform growers about the impacts (and benefits) of current and prospective practices. An important caveat is that models are valid only to the extent of the accuracy of their underlying data. Model assumptions, input parameters, and any data gaps need to be identified, and guidance for their use provided. This model series uses the Stella ® framework to simulate responses over time, facilitate development of models with varying complexities, a user-friendly interface, and the ability to publish and download completed models from an internet library. The developed models will function both independently or sequentially. The overarching goal of this model series is to help assess the impacts of current practices, and understand how changes may impact an operation. Additional models will aid in understanding pond dynamics, irrigation and runoff dynamics, nutrient uptake and loss, pesticide movement, and plant pathogen proliferation. Models for water treatment systems (e.g. vegetated buffers, floating wetlands) will also be developed and tested.

Specified Source(s) of Funding: U.S. Department of Agriculture: Award number 2014-51181-22372

4:30–4:45 PM

**Consumer Attitudes and Perceptions on Bioplastic Containers in the Horticulture Industry**

Kalynn Tan*
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William R. Graves
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James A. Schrader
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Heidi Kratsch
University of Nevada Cooperative Extension, Reno, NV

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University of Illinois, Urbana, IL

Melody Hefner
University of Nevada Cooperative Extension, Reno, NV

The objectives of this study were to assess horticultural consumer attitudes and willingness to pay for bioplastic containers as an alternative to the unsustainable petroleum-based plastic containers currently available. Consumers’ attitudes and willingness to pay were accessed through the use of in-person surveys and consumer preference studies. The surveys were conducted in 2015 at three different locations in Iowa and two locations in Nevada while the consumer preference studies took place in 2016 in various retail greenhouses in Iowa. Surveys queried consumers on such matters as to whether they were a frequent plant buyer, what kinds of container characteristics they considered when buying a plant from a garden center or greenhouse, whether they’d be willing to pay more for a plant in a bioplastic container, and how much more they would be willing to pay for the plant in a bioplastic container with attributes such as biodegradability, renewability, and fertilizer effect. A total of 287 horticultural consumers were surveyed with the results of the survey being overtly positive for the future marketability of bioplastic containers. Consumers indicated that they were most influenced by price (94% of respondents), ability to degrade in home compost or soil (78% and 80%, respectively), recyclability (67%), and fertilizer effect (67%). Further data analysis revealed that there was a strong correlation between

An asterisk (*) following a name indicates the presenting author.
an individual’s willingness to pay and their age or annual family income, which has implications for the segmentation and marketing of bioplastic containers.

4:45–5:00 PM

**Manipulation of Soilless Substrate Hydraulic Properties to Optimize Container Crop Water-substrate Interactions to Reduce Water Requirements**

Jeb Fields*
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Jim Owen
Virginia Polytechnic Institute & State University, Virginia Beach, VA

The ability to utilize natural resources more efficiently in production settings will allow for sustainable containerized crop production, thus increasing economic viability while reducing environmental impact. Improved understanding of soilless substrate water availability will allow for improved water use and management decisions. Conventional measures and guidelines for soilless substrate based, in part, on static physical properties must be challenged as fresh water availability becomes limited, regulated, or scrutinized. Hydraulic properties are utilized less frequent, but may be manipulated to improve the ability of a substrate to retain, distribute, and deliver higher proportion of water to the plant, thus increasing water use efficiency. Manipulation of the hydraulic conductivity of a substrate can shift water to capillary (water held in pores and readily available for plant consumption) from gravitational (readily drained) and hygroscopic (adsorbed to substrate particles), both of which are considered to be less available for plant uptake. The goal of this research was to determine how modifying soilless substrate hydraulic conductivity via altering particle size distribution and subsequent pore size distribution and/or connectivity will influence containerized crop growth and water use. Aged pine bark was screened and/or blended with fibrous amendments to yield seven substrates, four with varying particle size and two coarse pine-bark substrates amended with peat or coir, and a control aged pine bark with varying hydraulic properties as determined using the evaporation method. Twenty-seven replicates of *Hibiscus rosa-sinensis* ‘Fort Myers’ plugs were planted in 3.9-L containers using each substrate and automatically irrigated to maintain a water potential of –50 to –100 hPa; termed water buffering capacity, with the use of lysimeters that monitored substrate water content every five minutes. Crops were grown until a salable crop was achieved, with growth index and water use efficiency measurements being recorded over time. At the completion of the study, plant biomass was partitioned and leaf samples collected for analyses. Growth and biomass measurements followed a similar trend; plants grown in substrates with finer sized particles and increased pore connectivity able achieved higher growth rates (P < 0.0001). Crop water use efficiency as estimated via carbon isotope (13C) discrimination increased as substrate macropore volume decreased (P = 0.0307). Modifying substrate hydraulics can increase the proportion of water that is available to plants by transitioning water from gravitational and hygroscopic water to capillary water, thus further extending water availability in bark based substrates used to produce containerized crops throughout the United States.

**Specified Source(s) of Funding:** Funding for this work was provided in part, by the Virginia Agricultural Experiment Station, J. Frank Schmidt Family Charitable Foundation, Virginia Nursery and Landscape Association, and Pacific Organics.

5:00–5:15 PM

**Carbon Footprint and Variable Costs of Production Components for a Container-grown Evergreen Shrub**

Dewayne Ingram*
University of Kentucky, Lexington, KY

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

Joshua Knight
University of Kentucky, Lexington, KY

Using an east-coast nursery scenario, the production components of an evergreen shrub (*Ilex crenata* ‘Bennett’s Compacta’) grown in a #3 container were analyzed for their costs and contributions to carbon footprint using Life Cycle Assessment (LCA) methods. A life cycle inventory included input materials, equipment use, and all cultural practices and other processes utilized in a model production system for this evergreen shrub. Greenhouse gas emissions (GHG) and their global warming potential (GWP; kg CO2e), and variable cost of each component of the model system were determined. Transportation and transplanting of the final product in the landscape as well as its removal after a 40-year useful life were also included. GHG emissions from input products and processes during the production (cutting-to-gate) of the evergreen shrub were estimated to be 2.918 kg CO2e. When considering carbon sequestration during production, weighted over a 100-year assessment period, the carbon footprint for this model system at the nursery gate was 2.144 kg CO2e. Operations combining the impact of material and equipment use that contributed most of GHG emissions during production included fertilization (0.707 kg CO2e), the liner and transplanting (0.461 kg CO2e), the container (0.468 kg CO2e), gravel and ground cloth installation (0.222 kg CO2e), substrate materials and preparation (0.227 kg CO2e), and weed control (0.122 kg CO2e). The major contributors to GWP also added the most to the cutting-to-gate variable costs ($3.224) except for processes that required significant labor and little equipment investments. Postharvest activities would result in GHG emissions of 0.376, 0.458, and 0 kg CO2e for transporting the shrub to the landscaper, transporting it to the landscape site and transplanting it, respectively. Variable costs for postharvest activities were $6.409 and were dominated by labor costs (90%).

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

Analysis of nursery crop production systems using LCA has led to a greater understanding of the major contributing factors to GWP and variable costs. The cutting-to-landscape GWP of a container-grown evergreen shrub was estimated to be less than the accumulated, weighted impact of annual carbon sequestration during its useful life in the landscape. Such information will inform nursery managers and equip them for making better decisions on production protocols, market area, and ways to communicate the economic and environmental value of their products to the consuming public.

Specified Source(s) of Funding: This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crop Research Initiative, under award number 2014-51181-22372.

Oral Session—Environmental Stress

Physiology 1

Moderator: Renae Moran
University of Maine, Monmouth, ME

4:00–4:15 PM

Pre-plant Inhibition of Ethylene Signaling Alleviates Transplant Stress Responses and Improves Yield of Tomato

Shinsuke Agehara*
Gulf Coast REC, University of Florida, Wimauma, FL

Shipping and transplanting can cause a high degree of mechanical stress in vegetable transplants. Ethylene biosynthesis is commonly increased under mechanical stress to induce downstream stress responses and reduce overall growth. In this study, it was hypothesized that ethylene is the primary hormone inducing stress responses during transplanting and limiting transplant performance in the field. Therefore, the objective of this study was to examine if inhibiting ethylene signaling prior to transplanting can improve field establishment and yield of tomato. 1-Methylocyclopropene (1-MCP) was used to inhibit ethylene signaling by blocking ethylene receptors. Tomato seedlings (‘Florida 47’) were treated with 1-MCP at 0, 12.5, and 50 mg/L one day before transplanting. Post-planting growth was significantly accelerated by 1-MCP, with plant height increasing by 7% to 12% at the flowering stage. At the time of harvest, the 1-MCP-treated plants had 17% to 19% larger shoot biomass and 10% to 14% more flowers than the control plants. Consequently, both extra-large fruit and total marketable fruit yields were significantly increased by 1-MCP by up to 51% and 25%, respectively. The magnitude of growth and yield promoting effects by 1-MCP was similar for the two tested concentrations. These results suggest that inhibiting ethylene signaling by 1-MCP is an effective strategy to alleviate undesirable stress responses and improve the performance of vegetable transplants.

4:15–4:30 PM

Could Base Temperatures be Negative for Grapes? Deacclimation of Cultivated and Wild Grapes in Controlled Environment

Alisson Pacheco Kovaleski*
Cornell University, Ithaca, NY

Jason Londo
USDA-ARS Grape Genetics Unit, Geneva, NY

Grapevines (Vitis spp.) are native to temperate and subtropical climate zones, predominantly in the Northern Hemisphere. In order to survive winter temperatures, perennial plants such as grapevines developed dormancy mechanisms. Ecudormant buds are responsive to heat accumulation, leading to deacclimation, budbreak, and growth. The objective was to determine the deacclimation base temperature ($T_{base}$) and rate of different Vitis species. Four species were used: $V$. aestivalis, $V$. amurensis, $V$. riparia, and $V$. vinifera. For $V$. vinifera, four cultivars were used (‘Cabernet Franc’, ‘Cabernet Sauvignon’, ‘Riesling’, and ‘Sauvignon Blanc’), and two genotypes for $V$. riparia (588562 and 588711). Single node cuttings were collected in early March from vineyards located in Geneva, NY, and placed in growth chambers. Cuttings were exposed to five different temperatures ($T_{storage}$): 2, 4, 8, 10, and 22 °C. Using an arbitrary $T_{base}$ of 0 °C, samples were collected in ~20 growing degree-days (GDDs) intervals for differential thermal analysis (DTA), using low temperature exotherms as a measurement of deacclimation. Multiple linear regression was used to determine the actual $T_{base}$ for deacclimation of each genotype based on DTA data. GDDs were then calculated for each collection time point for all genotypes. A model was then used to calculate deacclimation rates based on GDD. ANOVA showed no differences for $T_{base}$ between the genotypes of either $V$. vinifera and $V$. riparia, indicating that this characteristic might be defined by the species. The base temperature was lowest for $amurensis$, at −4.12 °C, followed by $riparia$ (−1.13 °C) and $aestivalis$ (−0.21 °C). The highest $T_{base}$ was of $vinifera$ at 1.35 °C. The rates of deacclimation were also not affected by genotypes within species, but there was a significant interaction between species, GDD, and $T_{storage}$. $V$. aestivalis had the highest rate of deacclimation (0.143 °C/GDD at 10 °C), followed by $amurensis$ and $riparia$ (0.084 and 0.080 °C/GDD at 10 °C, respectively). $V$. vinifera had the lowest deacclimation rate: 0.044 °C/GDD at 10 °C. Although $aestivalis$ had a higher deacclimation rate than $amurensis$, $amurensis$ accumulates GDDs much faster due to its lower $T_{base}$. $V$. vinifera had the highest $T_{base}$ and lowest deacclimation rate, resulting in a very slow deacclimation compared to the other species. Therefore, $vinifera$ hybrids made from crosses with any of the other species tested could result in more rapid deacclimation rate, which may be detrimental if used in breeding programs for places with erratic spring weather.
**Simulation of Growth, Fresh Weight, and Size of Individual Tomato Fruits and Total Production Under Water and Nitrogen Limitations**

Kenneth Boote*
University of Florida, Gainesville, FL

Raquel Rybak
EEA-INTA, Cerro Azul, Argentina

James Jones
University of Florida, Gainesville, FL

Lincoln Zotarelli
University of Florida, Gainesville, FL

Fruit fresh weight size distribution, water content, and concentration of carbon compounds determine tomato production value for fresh market purposes. Tomato (*Solanum lycopersicum*) requires optimum water and nitrogen fertilization to obtain high yield and fruit quality. Crop growth models may be valuable tools to understand the impact of water and N fertilization management on tomato production. The CROPGRO-Tomato model accounts for water deficit effects on processes through two reducing factors called SWFAC (for effects on processes such as photosynthesis) and TURFAC (for effects of water deficit on expansive processes). A similar approach is used to compute daily N stress based on N supply to demand ratio. Fruit fresh weight and size are presently computed in the model based on simulated dry weight per fruit, a dry matter concentration that varies as a function of fruit physiological age, and a diameter function dependent on fresh weight per fruit. But there are insufficient connections of CROPGRO’s simulation of water or N stresses to dry matter concentration, timing, and size (fresh weight) growth of individual fruits. In this work the model was modified to use SWFAC or TURFAC as signals to affect dry matter concentration of fruits, and to alter fresh mass and size. The signals were also used to affect the timing of fruit growth under stress. Water deficit was allowed to increase the lag of the start of the fruit growth period for later-set fruits, and also used to accelerate maturation resulting in potentially shorter total fruit growth duration. Thus, these factors were strategically connected to fruit addition and dry matter growth rate of individual fruits and fruit thermal time accumulators. The CROPGRO-Tomato model, with these modifications, was then evaluated as a tool for predicting the dynamic growth of individual fruit cohorts (size and fresh weight) and total fruit yield for a crop grown under water and N limitations. Effects of reducing factors SWFAC, TURFAC and NSTRES in the model were suitable to reproduce reduced plant growth and total fruit growth as well as individual fruit size and fresh weight under water and N deficits. The result was an improved ability of the model to mimic the dry weight and fresh weight growth and dry matter concentration behavior of individual fruits under stress.

*Specified Source(s) of Funding:* Graduate student supported by Argentina

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**Seasonal and Genotypic Variation in Apple Rootstock Cold Temperature Tolerance**

Renae Moran*
University of Maine, Monmouth, ME

Bryan J. Peterson
University of Maine, Orono, ME

Gennaro Fazio
USDA-ARS, Geneva, NY

John A. Cline
University of Guelph, Guelph, Canada

Xylem cold temperature tolerance in Oct. and Nov. 2014 was measured in 2-year old shoot pieces 6–8 cm in length from 13 apple rootstock cultivars in the Geneva series, 3 in the Vineland series, ‘M.9’ and ‘B.9’. Following exposure to temperatures as cold as –35 °C, injury was measured as xylem browning using a rating scale of 0 to 10 with 0 indicating no browning and 10 indicating browning in the entire tissue. Nonlinear regression was performed to estimate the inflection point and upper asymptote of a logistic sigmoid function of xylem browning vs. temperature. We used the 95% confidence interval of the upper asymptote to categorize and compare genotypes since the inflection point did not generally represent hardiness. In late October, most genotypes did not have significant discoloration until a temperature of –25 °C to –30 °C. G.935, G.3902 and G.4011 had the least amount of xylem injury at the coldest temperature, –35 °C, with a discoloration rating of 2 or lower. G.4013, G.4814, and G.5087 had a similar low level of injury, but a maximum rating that was greater than 2.0. The greatest injury occurred in G.41 and G.214, and these had a rating greater than 7.0. G.30, V5, V6, and V7 had maximum levels of browning at –35 °C in the range of 5.0 to 7.0, and were not significantly different from G.41. Intermediate browning occurred in M.9, B.9, G.4292, G.4814, and G.5257. In mid November, G.935, G.4011, and G.5087 had very little injury at –35 °C and a maximum rating of 2 or lower. M.9, B.9, G.214, G.3902, G.4013, V5, and V6 also had less injury than the most tender genotypes, but a maximum rating that was greater than 2.0. The greatest level of injury occurred in G.30, G.41, G.4292, G.4814, G.5257, and V7 with a maximum injury rating greater than 5.0, although in G.4814 and G.5257, injury was minimal below –35 °C.

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**ABA-induced Calcium Uptake in ‘Honeycrisp’ Apple ([Malus xdomestica (Borkh.)] Determined Using a Stable Calcium Isotope Tracer**

Lee Kalcsits*
Washington State University, Wenatchee, WA

Luca Giordani
Washington State University, Wenatchee, WA

Gregory van der Heijden
INRA, Champenoux, France

We used the 95% confidence interval of the upper asymptote to categorize and compare genotypes since the inflection point did not generally represent hardiness. In late October, most genotypes did not have significant discoloration until a temperature of –25 °C to –30 °C. G.935, G.3902 and G.4011 had the least amount of xylem injury at the coldest temperature, –35 °C, with a discoloration rating of 2 or lower. G.4013, G.4814, and G.5087 had a similar low level of injury, but a maximum rating that was greater than 2.0. The greatest injury occurred in G.41 and G.214, and these had a rating greater than 7.0. G.30, V5, V6, and V7 had maximum levels of browning at –35 °C in the range of 5.0 to 7.0, and were not significantly different from G.41. Intermediate browning occurred in M.9, B.9, G.4292, G.4814, and G.5257. In mid November, G.935, G.4011, and G.5087 had very little injury at –35 °C and a maximum rating of 2 or lower. M.9, B.9, G.214, G.3902, G.4013, V5, and V6 also had less injury than the most tender genotypes, but a maximum rating that was greater than 2.0. The greatest level of injury occurred in G.30, G.41, G.4292, G.4814, G.5257, and V7 with a maximum injury rating greater than 5.0, although in G.4814 and G.5257, injury was minimal below –35 °C.

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**An asterisk (*) following a name indicates the presenting author.**
Calcium (Ca) is a critical nutrient in plants that contributes to the structural integrity of cell walls, acts as a counter-cation for anion exchanges and is a critical messaging receptor for plant responses to environmental cues. In deciduous tree fruit, Ca plays a key role in quality. Localized deficiencies in Ca affect storability and susceptibility to storage problems. The pre-harvest conditions that contribute to the development of these Ca imbalances in fruit are poorly understood. Here, we sought to test the use of stable Ca isotopes as a tracer to explore Ca uptake and distribution in apple. In two separate experiments, ‘Gala’ and ‘Honeycrisp’ apple trees were selected for uniformity of size and caliber. Trees were grown for 60 days in a greenhouse at ambient conditions at the Tree Fruit Research and Extension Center in Wenatchee, WA. After 60 days of growth, abscisic acid (ABA) was applied at 500 mg L-1 to half of the trees and distilled water was applied to the other half as a control. In the first experiment, 2 mg of 97 atom% 44Ca tracer was applied to each 10 L pot. In the second experiment in 2015, 20 mg of 44Ca was used. ABA application reduced stomatal conductance and photosynthetic rates. In association with the changes in stomatal conductance, there was an immediate 40% reduction of water-use that slowly increased for 20 days until transpiration was closed to that of the control. Differences in water-use were confirmed using both gravimetrically and using a Li-COR 6400XT gas exchange system. Total leaf Ca concentration and 44Ca tracer uptake measurements were used to look at changes in Ca uptake. Differences in transpiration were expected to result in reduced Ca uptake. However, the opposite occurred. An increase in Ca uptake was observed in in plants treated with ABA. There was between 5% and 10% more calcium in leaves in trees treated with ABA compared to the control and this corresponded to an increase in the amount of 44Ca tracer in the plant. This was consistent across both cultivars. Here, we demonstrate an uncoupling of transpiration and Ca uptake when ABA-induced stomatal closure occurred. More work is needed to identify the mechanisms by which Ca uptake was affected. This work highlighted a new approach to look at Ca uptake and distribution in horticultural crops that frequently suffer from Ca-related disorders.

Specified Source(s) of Funding: Washington State University CAHNRS Emerging Research Issues Grant

Oral Presentations

Susan Barton
University of Delaware, Newark, DE

Thomas W. Ilvento
University of Delaware, Newark, DE

The 2015 Delaware Master Gardeners training simultaneously delivered content to two locations via Zoom video web conferencing (VWC) to increase training efficiency, demanding examination of trainee learning outcomes and experiences. Potential cost savings could be outweighed by shortened Master Gardener tenure or the loss of high quality horticultural education, which serves to recruit volunteers as a tangible benefit of the training, if remote delivery results in reduced learning. Prior research evaluating Master Gardner training suggested there would be no significant difference based on instructional mode. However, earlier studies did not focus on the application of learned materials. In order to evaluate the pilot implementation of VWC for remote delivery, trainees (n = 30) answered two open-ended application questions after eleven instructional sessions. Each group of participants received approximately half of the instruction face-to-face, while the other group simultaneously received instruction via remote delivery (n = 17; n = 13). Thus, we were able to investigate within-session and overall differences comparing face-to-face and remote delivery instruction. Prior studies’ results of no significant difference were replicated in this study when sessions were evaluated overall. However, when sessions were examined individually, individuals who received remote training via VWC scored significantly lower on two trainings (t = 2.25, P = 0.034; t = 3.73, P = 0.001). This suggests trainee experiences with VWC were likely impacted by session-specific variables such as the instructor, content, or technical challenges. We did not find significant differences for other sessions by the same instructors or covering the similar content, so we probed technical challenges further and asked trainees to evaluate the media naturalness of their overall VWC experience. Media naturalness, the extent to which media approximates face-to-face interaction, consists of five elements of communication. By investigating media naturalness, we not only evaluated if there were technical difficulties but also what component of interaction was negatively impacted. Results suggest overall low media naturalness [M = 1.88, SD = 0.51 (5-point scale)]. The ability to see the instructor’s facial expressions (M = 1.24, SD = 0.44) was the lowest scoring element, suggesting video stream or size limitations. As this was a post-hoc measure but applies differently to each session, future research should continue to investigate these findings by evaluating media naturalness by session. In order to make tangible improvement to remote instructional delivery, it is critical for Extension professionals to understand how the learning experience is impacted.

Specified Source(s) of Funding: Delaware Cooperative Extension

Oral Session—Consumer Horticulture/ Master Gardeners and Public Horticulture

Moderator: Natalie Bumgarner
University of Tennessee, Knoxville, TN

4:00–4:15 PM

Ensuring Quality: Evaluating the Implementation of Video Web Conferencing in Delaware Master Gardener Training

Emily Barton*
University of Virginia, Charlottesville, VA

An asterisk (*) following a name indicates the presenting author.
The Extension Master Gardener (EMG) program exists in 49 states, the District of Columbia as well as Canada and South Korea. It is not clearly known how many EMGs there are in the United States or how many hours of service are given in a year’s time. In the United States, the collection of impact data for the EMG program is up to each individual state; yearly data for the national EMG program is not collected. The last national data collection survey was completed in 2009 with 40 states responding; the EMG CSREES liaison provided leadership for this effort. In March 2015, the EMG National Committee distributed a survey in order to update the 2009 report. The 2014 report was completed and distributed in March 2015. This report shows only 38 of the 49 state programs reporting, indicating more than 80,000 EMGs donating more than 5,292,130 hours of service nationwide. Because of the fact that there is no consistent data collection tool for the U.S., the reported data doesn’t completely represent the EMG program in terms of number of volunteers, hours donated, etc. This session will discuss the challenges in national data collection and impact reporting and the need for a national data collection tool. Reporting impact is critical to the strength of the program nationally. The EMG has developed a task force to address this issue; the task force will create a consistent data collection instrument that can be adopted by each state EMG program. The EMG will be responsible for implementing this data collection and impact reporting.

4:30–4:45 PM

**Washington Tree Stewards Online Training**

Nicole Martini*

Washington State University, Puyallup, WA

While there is an abundance of information available to the public and Master Gardeners on trees for the private residence, there is very little on the stewardship of, and advocacy for, community trees. Washington State University (WSU) Extension partnered with the Washington State Department of Natural Resources (WSDNR) to develop online trainings on this topic to fill this need. The main objective of the training is to teach people to become educated advocates for trees and tree care in their communities. A statewide team of WSU Extension faculty and staff was formed to produce the training. The team met monthly via Zoom Video Conferencing. The course was designed in Blackboard by Global Campus (WSU’s distance learning center) in collaboration with the Tree Stewards Team. Quizzes were included to insure that students would acquire a basic level of knowledge. Upon successful completion of the training, students receive a certificate acknowledging they’ve taken and passed the training. Washington State University Extension now has a noncredit peer-reviewed online course available to those who want to learn more about tree stewardship and how to be an advocate for trees in their community. These advocates can play an important role in urban and community forest health management. Master Gardeners who have taken the training record the volunteer hours they spend on tree stewardship education in the WSU Online Volunteer Database. Other evaluation tools to be developed will show the impact of the training. The training is available as a self-paced course that does not require instructor facilitation.

Specified Source(s) of Funding: Washington State Department of Natural Resources

4:45–5:00 PM

**Taking the Demonstration Garden to the Next Level: The UT Gardens Crossville: Plateau Discovery Garden Model**

Natalie Bumgarner*

University of Tennessee, Knoxville, TN

William G. Upchurch

University of Tennessee Extension, Cumberland County, Crossville

Nancy Christopherson

Cumberland County Master Gardener Association, Crossville

John W. Hitch

University of Tennessee Plateau REC, Crossville

In the United States, public gardens have a well-established history of providing adults and students of all ages with horticultural education and serving as a site for research. These public gardens can take many forms including botanic gardens, arboreta, parks, nature preserves, zoological gardens, and display gardens; and several are affiliated with universities. However, it is relatively uncommon for public gardens to be collaboratively developed and operated by university research and Extension personnel and Extension Master Gardener volunteers. The collaboration of these three entities and the vision of those involved has led to the University of Tennessee Gardens–Crossville: Plateau Discovery Garden (UTG–C:PDG). In just over 10 years, what was begun as a demonstration garden has grown into a garden now recognized as one of three branches of University of Tennessee (UT) Gardens, the state botanical garden of Tennessee. The first critical element in the success of this garden was the collaborative partnership between 1) the UT Plateau REC, 2) the Cumberland County Master Gardener Association (CCMGA), and 3) the Cumberland County Extension office. Over the years, these three collaborators have focused on mutually beneficial decision-making through an umbrella committee. This joint leadership has enabled the combination of outreach, research, and teaching. Begun as demonstration garden to strengthen outreach efforts, the UTG-C:PDG now delivers year-round Extension education focusing on horticulture workshops, garden events, and participation in UT research field days as well as continuously hosting visitors. As a result of these efforts and capacities, research faculty now carry out research on ornamental as well...
as edible crops in the garden area. To support undergraduate education, an internship program is now in its 4th year. These multi-faceted internships introduce students to horticultural research and the commercial industry while engaging them in Extension outreach. This presentation will describe the unique collaboration and history of the UTG-C:PDG to serve as a possible model of volunteer, researcher, and Extension contributions that have the potential to directly benefit stakeholders through novel public gardens.

5:00–5:15 PM

**Longwood Gardens Fellows Program: Building Public Horticulture Leadership Capacity**

Tamara Fleming*
Longwood Gardens, Kennett Square, PA

Brian Trader
Longwood Gardens, Kennett Square, PA

Douglas Needham
Longwood Gardens, Kennett Square, PA

Since 1956, Longwood Gardens has trained and educated future generations of public horticulture professionals. With horticulture education evolving rapidly and the public garden profession facing new challenges, an innovative way to build leadership capacity is necessary. In June 2017, Longwood will welcome the first cohort into the Longwood Gardens Fellows Program. This mission-based Program will integrate a 13-month immersive experience, leveraging the wealth of gardens in the Philadelphia region, with experiential learning opportunities delivered through collaborative group projects, case studies, externships, and salon-style meetings with leading industry professionals. The Fellows Program curriculum will include content areas such as strategic planning, board development, fundraising, human resources and non-profit management, succession planning, and other topics relevant to the daily operations of public gardens. Working as a cohort, Fellows will choose and complete a yearlong project that addresses a particular challenge facing the public horticulture profession, while being mentored by Longwood’s staff. A field placement to a partner garden will allow Fellows to experience first-hand the operations of another institution, while having a practical experience tailored to their personal interest and career goals. Highly motivated candidates at entry- and mid-level careers from across the United States and around the world are eligible to apply for this fully funded, residential program at Longwood Gardens. Recruitment for the Fellows Program will begin in Summer 2016 with an application deadline later this fall.

5:15–5:30 PM

**Redefining Garden Restoration in Yorkshire: Goddards Case Study**

Gail Hudson*
University of Minnesota, Minneapolis, MN

“An amazing gem of a garden”—that’s how the head gardener describes a small Arts and Crafts property in northern England called Goddards. Goddards was designed from 1925 to 1935 by garden architect George Dillistone, whose style has been likened to world famous garden designer Gertrude Jekyll. While Goddards is not a Sissinghurst or of Hampton Court fame, it is a historical National Trust garden worthy of attention for the lessons it can teach us in how contemporary restorations are currently being redefined. This case study examined the challenges and issues that surfaced during Goddards’ ongoing restoration process. Goddards’ on-site managers pursued the lofty goals of historical conservation and restoration, with extensive archival information in hand such as landscape designs, drawings, plant lists, correspondence, photographs and memories. But Goddards’ caretakers continued to struggle with the demands of day-to-day maintenance, a limited budget, limited resources, a small staff, and The National Trust’s “one-size-fits-all” guidelines. Other factors often stood in the way of the goals of restoration such as the garden’s changing conditions, the “every day” priorities of the garden’s caretakers (which may conflict with a restoration or compromise it), gaps in historical documentation and the safety concerns and needs of visitors. A “small cog” in the National Trust’s wheelhouse, the garden’s future has been tenuous as it competed for the attention and a firm commitment by the administrators of this national charity to move forward. The National Trust’s own restoration history has influenced what and how restoration was taking shape at Goddards. The Trust is considered a pioneer in restoration through its care for more than 350 historic sites across England, Wales, and Northern Ireland. And yet, it’s only been since the turn of the 21st century that the Trust has truly advanced its philosophy and approach to conservation. Leaders at the trust have developed a conservation toolkit that includes its six principles of conservation, a Consumer Performance Indicator assessment process, “Statements of Significance” developed for each property, as well as a value scale. These developments have changed the way restoration and conservation is now currently understood and implemented in the United Kingdom and ultimately has influenced the restoration hopes and futures for gardens everywhere.

5:30–5:45 PM

**Exploring Culinary Arts Programs at Public Horticulture Institutions**

Susan Barton
University of Delaware, Newark, DE

Mackenzie Fochs*
University of Delaware, Newark, DE

Douglas Needham
Longwood Gardens, Kennett Square, PA

Thomas W. Ilvento
University of Delaware, Newark, DE

Susan Crane
Morris Arboretum, University of Pennsylvania, Philadelphia, PA

Demand for food and beverages that are locally grown and made, organic, and nutritious has been on the rise in recent
years, and many public gardens are recognizing the interest in and need for programming about these topics. Public gardens are also seeking to reach a diverse audience and culinary programs may help accomplish this goal. This research sought to answer the question, “What do public horticulture institutions gain, if anything, from providing culinary event programs and culinary education programs?” Objectives to answer this question were: to define the variety of culinary arts programs offered at public horticulture institutions and understand how they fit with the mission of each institution; to define demographics of culinary arts program participants at five public horticulture institutions; to understand the difference between culinary programs and other education programs in their effect on membership and feeling of connection to the institution; to determine impact of culinary arts programming on the decisions participants make related to program topics; and to provide best practice recommendations for public horticulture institutions interested in developing culinary arts programs. Interviews were conducted with 32 professionals involved in culinary arts programming at 21 public horticulture institutions across the United States. Surveys were sent to past participants in culinary programs and other education programs through five institutions from the interview group. Results indicate there is a distinct audience who specifically attends culinary arts programs. There are some statistical differences between culinary programs and other education programs in membership and feeling of connection to the institution. Participants in culinary programs were inspired to grow vegetables, herbs, or fruit, purchased locally grown food, and tried new things more after attending a culinary program. Best practice recommendations include considering factors such as available facilities, pricing and supply costs, volunteers, instructors, partnerships, and sponsorships.

Oral Session—Pomology 2

Moderator: Whitney Garton
Washington State University NWREC, Mount Vernon, WA

Management of Apple Anthracnose Canker
Whitney Garton*
Washington State University NWREC, Mount Vernon, WA
Mark Mazzola
USDA-ARS, Wenatchee, WA, USA
Carol Miles
Washington State University, NWREC, Mount Vernon, WA

Apple anthracnose (caused by Neofabraea malicorticis anamorph Cryptosporiopsis curvispora) is a fungal disease that causes cankers on trees and ‘Bull’s-eye rot’ on fruit. In western Washington, it is the canker phase of apple anthracnose that is considered most serious as it can result in death of newly planted trees and reduce the overall health and yield of established trees. A study was conducted at Mount Vernon, WA, in 2014 and repeated in 2015 to evaluate 5 treatments to manage cankers in cider apple trees: 1) carve out canker, spray carved area with 10% bleach solution; 2) carve out canker, spray carved area with Nu-cop (copper fungicide); 3) carve out canker, burn carved area with hand-held propane torch; 4) carve out canker, burn carved area with hand-held propane torch and spray Nu-cop; 5) completely cover canker and additional 1cm margin with Bordeaux paste; and 6) carve out canker, apply Bordeaux paste on carved area (2015 only). These are all common practices used in the region to manage cankers, however their efficacy has not been tested. Treatments were applied once to new canker infections, on 16 Dec. 2014 and 11 Dec. 2015; different trees were included in the study each year. Prior to treatment application, the canker area was measured and there were no differences in canker size on trees assigned to treatments (average canker size 0.49 cm). Each year the treated area following canker removal was measured immediately after treatment application and every 2 weeks thereafter. Significant differences (P < 0.0001) were found due to treatments at each measurement time. The increase in removed canker area following each treatment was: treated with propane burning increased 86% in 2014 and 588% in 2015 as compared to the canker area immediately after treatment application. The removed canker area treated with propane burning + nu-cop increased 122% in 2014 and 1463% in 2015. The removed canker area treated with Nu-cop had a 2% increase in 2014 and a 28% increase in 2015. The removed canker area treated with bleach increased 25% in 2014 and 6% in 2015. The canker area treated with Bordeaux paste decreased 0.4% in 2014 and increased 10% in 2015. The removed canker area treated with Bordeaux mixture increased 5% by 9 weeks in 2015. In follow-up assays, the fungus in all treatments appears to still be active.

4:30–4:45 PM

High Susceptibility of ‘Honeycrisp’ Apple to Bitter Pit Is Associated with Low Fruit Calcium Level and Its Imbalance with Other Nutrients
Huaiyu Ma
Cornell University, Ithaca, NY
Yongzhang Wang
Cornell University, Ithaca, NY
Lailiang Cheng*
Cornell University, Ithaca, NY

‘Honeycrisp’ is highly susceptible to bitter pit, but its underlying cause is not well understood. In this study, we compared fruits with and without bitter pit of ‘Honeycrisp’ and also with ‘Gala’, a variety not susceptible to bitter pit, in terms of fruit Ca level and its balance with other nutrients. Two types of tissues were sampled for ‘Honeycrisp’ fruit with bitterpit: pitted tissue and apparently healthy outer cortex tissue at the calyx end. The apparently healthy cortex tissue of ‘Honeycrisp’ fruit with bitterpit had a lower Ca level, but the pitted tissue had a higher Ca level than that of fruit without bitter pit (CK). There were comparable levels of K, Mg, and P between the apparently healthy cortex tissue and the CK, but the pitted cortex tissue accumulated higher levels of K, Mg, and P than the CK. The

An asterisk (*) following a name indicates the presenting author.
apparently healthy peel of fruit with bitter pit had significantly lower Ca level than the CK, with the pitted peel having the lowest Ca concentration. In contrast, the apparently healthy peel of fruit with bitter pit had significantly higher levels of K and P than the CK, with the pitted peel having the highest concentrations of K and P. As a result, the apparently healthy peel and the pitted peel have higher values of K/Ca, (K+Mg)/Ca and P/Ca. Measurements of nutrients in the apoplastic fluid indicate that the apparently healthy cortex tissue and pitted tissue of fruit with bitter pit had similar concentrations of apoplastic Ca, but higher concentrations of apoplastic K and P than fruit without bitter pit. Compared with ‘Gala’, ‘Honeycrisp’ fruit without bitter pit had much lower concentrations of Ca in both cortex tissue and peel, but comparable levels of K, Mg and P in cortex tissue and significantly higher levels of K and P in peel, resulting in higher values of K/Ca, Mg/Ca, (K+Mg)/Ca, and P/Ca in both cortex and peel. In addition, ‘Honeycrisp’ leaves had a higher level of Ca, but lower levels of P, K, and Mg than in ‘Gala’. These results suggest that 1) imbalance of Ca with other nutrients is closely associated with bitter pit development in ‘Honeycrisp’ and 2) ‘Honeycrisp’ has a more acute partitioning of calcium between leaves and fruit than ‘Gala’, leading to a much lower Ca level and higher ratios of K/Ca, (K+Mg)/Ca and P/Ca in fruit, which may make the fruit more susceptible to bitter pit.

**Specified Source(s) of Funding:** New York Apple Research and Development Program

4:45–5:00 PM

**Irrigation and Fertilization Rates for Young Peach Trees [**Prunus persica** L. (Batsch)]**

Bruno Casamali*
University of Georgia, Athens, GA

Dario J. Chavez
University of Georgia, Griffin, GA

Marc van Iersel
University of Georgia, Athens, GA

In the southeastern United States, peach trees [**Prunus persica** L. (Batsch)] fruit production starts after three years of field establishment. During these years of establishment, peach trees are not irrigated relying only on natural precipitation as their only water source. Similarly, fertilizer recommendations are not well specified, leaving room for yield improvement. Further studies are needed to determine the effect of early irrigation and fertilization management in peach orchards. Current recommendations make no distinction among cultivars in terms of water and nutrient requirements. Some rootstocks may exhibit drought or waterlogging resistance, which can be important for growers who may want to expand peach production to areas with low water availability or which suffer from less than ideal drainage. The objective of this research was to evaluate the effects of different irrigation and fertilization rates in young peach trees. The experiment was conducted in a greenhouse. Four scion/rootstock combinations were tested (‘Julyprince’ and ‘Flavorich’ grafted onto ‘MP-29’ or ‘Guardian’). Plants were grown in 14.6-L pots, in Fafard Mix 2 substrate. Three irrigation treatments (substrate volumetric water content of 0.15, 0.30, and 0.45 m\(^3\) m\(^{-3}\)) were imposed using a datalogger in order to control the irrigation. Three fertilization rates 24.7, 49.3, and 74 kg of nitrogen per hectare per year were applied using a granular fertilizer. Data on plant growth, trunk diameter, bud breaking progression, leaf nutritional content, stomata density, leaf gas exchange, and stem water potential were collected and compared between treatments and between different scion/rootstock combinations.

An asterisk (*) following a name indicates the presenting author.
the epidermins and cortex of ‘Honeycrisp’ ABA-treated apple tissues. Shoot length in the ABA-treated trees was reduced compared to the untreated control trees. This study concluded that S-ABA is a promising tool for bitter pit control in sensitive apple varieties, such as ‘Honeycrisp’.

5:15–5:30 PM

**Biochar Amendments As an Alternative to Manage Peach Replant Disease**

Amaya Atucha*

University of Wisconsin-Madison, Madison, WI

The present study explores the effects of biochar as a soil amendment to alleviate replant disease (RD) in peach trees. The use of RD tolerant rootstocks has become a valuable alternative to manage replant in apple orchards; however there are currently no RD tolerant rootstocks available for stone fruits, and conventional management of this soilborne disease with soil fumigants is limited due to the global phase-out of methyl bromide. Exploring new alternatives to mitigate the effects of RD through the use of organic amendments may be an environmentally sound and sustainable solution to manage RD in stone fruits. The use of biochar as a soil amendment to improve soil fertility has generated great interest all over the world, and its effects on soil biological properties have shown promising results on the control of soilborne diseases. The objective of the present study was to evaluate the effect of biochar on peach tree growth; biomass production and nutritional status under replant conditions. Peach trees were grown in pots in a greenhouse under 4 soil treatments: soil collected from a peach replant site (control), sterilized soil (sterilized), and biochar-amended soil at 10% and 20% (v/v) (low biochar and high biochar, respectively) all from the same peach replant site. Tree growth was measured weekly by recording trunk diameter increase. A subsample of trees were harvested at 11, 22, and 33 weeks after planting and total above and below ground biomass production was recorded for each date. Soil, foliar, and root samples were collected at each harvest date and were analyzed for nutrient content. Results showed significantly higher above and below ground biomass production in the biochar and sterilized soil treatments compared to the control. During the final harvesting date, soil nitrogen concentration was greater in the high biochar treatment, and foliar magnesium concentrations were significantly higher in both biochar treatments for all harvesting dates. Carbon content of first and second order roots was significantly higher in the high biochar treatment compared to the control. Based on the results of this study, applications of biochar to replant soils could alleviate RD in peach trees.

5:30–5:45 PM

**Effect of Nitrogen Fertilization and Harvest Time on Volatile Profile, Sensory Attributes, and Consumer Preference of Low-chill Peaches**

Tripti Vashisth*

University of Florida, Lake Alfred, GA

Commercial peach acreage continues to increase in Florida as citrus growers look to diversify their orchards. Breeding of low-chill peach cultivars have made it possible to grow peaches in subtropical climates. However, fertilization practices must be optimized for this longer growing season. Nutrient guidelines for optimum peach tree growth and fruit yield have been established in temperate areas and are being translated for use in subtropical climates; however, the effect of nitrogen fertilization on important peach fruit attributes like flavor and aroma and sensory perception is unknown. Another important factor crucial for the fresh fruit market is harvesting time, as harvesting can influence several fruit characteristics. Therefore, the objective of this research was to evaluate effect of different nitrogen rates on ‘TropicBeauty’ and ‘UFSharp’ as well evaluate the effect of harvesting time on ‘TropicBeauty’. Peach volatile compounds were analyzed by gas chromatography, with a total of 49 volatile compounds significantly affected as a result of harvesting time. Twenty-seven volatile compounds were found to be significantly different among ‘TropicBeauty’ and ‘UFSharp’, out of which 15 showed a significant genotype*nitrogen rate interaction. These compounds included lactones, acetates, alkane hydrocarbons. Consumer sensory panel suggested that cultivar differences were perceived but not among different nitrogen rates. As expected, decreased firmness was observed with late harvest. Interestingly, a significant genotype*harvest date interaction was observed and firmness decreased with increasing rates of nitrogen. Overall, our data suggests nitrogen rate and harvest time plays an important role in harvested fruit attributes and therefore, can be strategically manipulated to satisfy consumer demand.

5:45–6:00 PM

**Revisiting Cold Hardiness of Peaches in Georgia**

Jun Liu*

University of Georgia

Anish Malladi

University of Georgia, Athens, GA

Orville Lindstrom

University of Georgia, Griffin, GA

Erick Smith

The University of Georgia, Tifton, GA

Mercy Olmstead

University of Florida, Gainesville, FL

Dario J. Chavez

University of Georgia

Commercial peach acreage continues to increase in Florida as citrus growers look to diversify their orchards. Breeding of low-chill peach cultivars have made it possible to grow peaches in subtropical climates. However, fertilization practices must be optimized for this longer growing season. Nutrient guidelines for optimum peach tree growth and fruit yield have been established in temperate areas and are being translated for use in subtropical climates; however, the effect of nitrogen fertilization on important peach fruit attributes like flavor and aroma and sensory perception is unknown. Another important factor crucial for the fresh fruit market is harvesting time, as harvesting can influence several fruit characteristics. Therefore, the objective of this research was to evaluate effect of different nitrogen rates on ‘TropicBeauty’ and ‘UFSharp’ as well evaluate the effect of harvesting time on ‘TropicBeauty’. Peach volatile compounds were analyzed by gas chromatography, with a total of 49 volatile compounds significantly affected as a result of harvesting time. Twenty-seven volatile compounds were found to be significantly different among ‘TropicBeauty’ and ‘UFSharp’, out of which 15 showed a significant genotype*nitrogen rate interaction. These compounds included lactones, acetates, alkane hydrocarbons. Consumer sensory panel suggested that cultivar differences were perceived but not among different nitrogen rates. As expected, decreased firmness was observed with late harvest. Interestingly, a significant genotype*harvest date interaction was observed and firmness decreased with increasing rates of nitrogen. Overall, our data suggests nitrogen rate and harvest time plays an important role in harvested fruit attributes and therefore, can be strategically manipulated to satisfy consumer demand.

5:30–5:45 PM

**Effect of Nitrogen Fertilization and Harvest Time on Volatile Profile, Sensory Attributes, and Consumer Preference of Low-chill Peaches**

Tripti Vashisth*

University of Florida, Lake Alfred, GA

Temperature plays a leading role in limiting plant distribution on Earth. Critical bud freezing temperature is the temperature at which buds are injured or lethally damaged by low temperature. The knowledge of this critical freezing temperature can help peach growers determine and avoid potential economic loss before and after a freeze. The objective of this study was to revisit the critical bud freezing temperature of two peach cultivars, ‘Elberta’ (850 chill hour) and ‘Flavorich’ (700 chill hour).
hour), and to study various techniques to determine the critical bud freezing temperature through the winters of 2014–15 and 2015–16 in Fort Valley, GA. A traditional freezing test was used to determine the freezing tolerance of floral buds, vegetative buds, and stems. Samples of excised floral and vegetative buds, 5 cm stems, and 20 cm stems, were evaluated for visual damage after controlled freezing experiments. The controlled freezing test was conducted at a freezing rate of 4 °C/h and within a temperature range of −3 °C to −27 °C. Critical bud freezing temperature was determined as the lethal bud temperature at 50% mortality (LT50). Across the two years, difference in cold hardiness was reported among cultivars (P < 0.0001). 'Elberta' flower buds were significantly harder than 'Flavorich'. Both cultivars developed cold hardiness in the fall during the cold acclimation stage, and reached the maximum levels of cold hardiness around Jan 28 in both years. Cold hardiness decreased after late January, with 'Flavorich' cold deacclimation occurring quicker and blooming earlier than 'Elberta'. Excised flower and vegetative buds had higher critical bud freezing temperature when compared to their counterparts still attached to the stems (P < 0.0001). Stem cold hardiness was maintained even after floral buds deacclimated. The results provided will help to better understand the mechanisms that peaches use to survive low temperature. The information presented will aid to compare and to understand new techniques that could be used to better determine the critical bud freezing temperature of peaches and help growers with real-time information for upcoming freezing events.

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

Wednesday, August 10, 2016

Oral Session—Growth Chambers and Controlled Environments 2

Moderator: Michael Martin
University of Georgia, Athens, GA

8:00–8:15 AM

Improving Production Efficiency in Controlled Environment Agriculture By Utilizing Remote Sensing Technologies

Krishna Nemali*
Purdue University, West Lafayette

Marc van Iersel
University of Georgia, Athens, GA

Controlled environment agriculture (CEA) systems for specialty crops (floriculture and vegetables) use high amounts of inputs (including light, water and nutrients) and cost more per unit growing space than other production systems. Improving production efficiency is crucial for the economic viability and sustainability of CEA systems. One approach to improving production efficiency in CEA systems is to optimize input use by precisely monitoring and adjusting the input supply based on “plant needs.” However, this is challenging given the high plant density per unit growing space in CEA systems. Advanced sensing technologies interfaced to automation may provide solution to this challenge. Input adjustment based on “remote sensing” of plant responses (i.e., precision agriculture) is being successfully used by farmers under conventional agriculture in the United States. Although advanced sensing technologies are more suitable in CEA than conventional agriculture, their use has been very limited in CEA. This presentation will explore how remote sensing can be used to monitor crop growth, water and nitrogen status of plants in CEA production systems.

8:15–8:30 AM

Uniform Spectrum LED Film Illumination Device (FID), the Next Generation Lighting System for Indoor Horticulture and Farming

Grace Liu
University of Minnesota, St. Paul, MN

Ryan Murphy
University of Minnesota, St. Paul, MN

Garry Du
3M, Mapplewood, MN

Minghua Dai
3M, Mapplewood, MN

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

Recent development of a uniform spectrum LED film illumination device (FID) by the New Horizon Lab at 3M is revolution-
In indoor growing systems or other applications where supplemental lighting is used, it is important to understand what light levels are ideal for plants without causing damage to the photosynthetic apparatus. Nighttime quantum yields of photosystem II and maximum chlorophyll fluorescence data can be used as benchmarks for plant recovery after exposure to light and as an indication of photoinhibition and photodamage. Green Towers lettuce plants were grown inside a grow chamber at photosynthetic photon flux of 280 μmol·m⁻²·s⁻¹. Using a chlorophyll fluorescence-based biofeedback control system that adjusts LED lighting to maintain desired electron transport rates (ETRs) through photosystem II, lettuce plants were maintained at constant ETRs for 14 hours with 10 hours of dark. The ETRs ranged between 50 and 120 μmol·m⁻²·s⁻¹, in steps of 10 μmol·m⁻²·s⁻¹, for a total of 8 ETRs. Photosynthetic photon flux ranged from 125 to 520 μmol·m⁻²·s⁻¹ for plants with ETRs of 50 to 90 μmol·m⁻²·s⁻¹, and from 340 to 520 μmol·m⁻²·s⁻¹ for plants with ETRs of 100 to 120 μmol·m⁻²·s⁻¹. The nighttime yields of plants exposed to ETRs of 90 and below returned to values comparable to those during the previous night, while plants maintained at ETRs above 90 did not fully recovered during the subsequent dark period. This lack of recovery indicates damage to photosystem II caused by relatively high light levels. Maximum fluorescence in plants maintained at ETRs above 90 did not fully recovered during the subsequent dark period. This lack of recovery indicates damage to photosystem II that was damaged by the high light levels (> 300 μmol·m⁻²·s⁻¹) during the preceding day.

8:45–9:00 AM

Comparison of FDR Sensor Calibrations for Various Coir Dust and Perlite Mix Ratios

Jongyun Kim*
Korea University, Seoul, Korea, The Republic of
Yong Ha Rhie
Korea University, Seoul, Korea, The Republic of
Jong-Myung Choi
Chungnam National University, Daejeon, Korea, The Republic of

Recently developed FDR (frequency domain reflectometry) soil moisture sensors are suitable for measuring volumetric water contents (VWC, v/v) of horticultural substrates in real time, which can provide a good tool for substrate moisture based-automated irrigation of horticultural crops. For FDR sensors, substrate-specific calibration is required to acquire accurate measurements of VWC, but sensor companies typically provide only a general calibration for all potting soils (and sometimes no specific calibration for horticultural substrates), which cannot represent the variety of horticultural substrates. To investigate and compare the substrate specific calibrations for various coir dust and perlite mix ratios (1:0, 8:2, 6:4, 4:6, 2:8, 0:1, v/v), we conducted individual calibration in a range of 0.1 m³·m⁻³ to near the container capacity for each substrate mix. Sensor outputs (in mV and ADC) of various VWC levels of the specific substrates were collected with four EC-5 and GS3 sensors (Decagon Devices Inc., Pullman, WA, USA) connected to CR1000 data logger (Campbell Scientific Inc., Logan, UT, USA) with 2.5 V-DC and 12 V-DC excitation, respectively. Regression analyses were conducted to acquire VWC calibration equations for each substrate mix. The actual VWC level was calculated as (acet substrate weight - dry substrate weight) (g) / substrate volume (mL) after drying the substrate in a drying oven. All the tested substrate mixes had linear relationship between EC-5 sensor output and VWC with high R² (> 0.93) except 100% perlite, and their slopes were significantly different across the substrate mixes (P = 0.03). However, most of the substrate mixes had the similar calibrations with the estimated VWC differences within 0.06 m³·m⁻³. GS3 data had the best fit with a logarithmic relationship between sensor output (ADC) and VWC, and the slopes among the substrate mixes were not significantly different (P = 0.13). Furthermore, the potting soil calibration equation provided by the company differed from the substrate-specific calibration equations, resulting in large errors (up to 0.5 m³·m⁻³ difference) in measuring actual VWCs. Therefore, substrate-specific calibration is required to acquire accurate VWC measurements with FDR sensors.

Specified Source(s) of Funding: This research was supported by Advanced Production Technology Development Program of Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries.

9:00–9:15 AM

Enhancing Photosynthesis with Far-red Light at Different Intensities of Red/Blue or Warm White LED Light

Shuyang Zhen*
University of Georgia, Athens, GA
Marc van Iersel
University of Georgia, Athens, GA

Light emitting diodes (LEDs) are increasingly used for supplemental lighting to increase photosynthesis or as the sole lighting source for indoor production of high value crops. To achieve maximum photosynthetic efficiency, light needs to provide a balanced excitation of photosystems I and II, which have different absorption and action spectra. Using lettuce (Lactuca sativa) as a model system, we found that far-red light (peak at 735 nm) has a synergistic effect on the light reactions of photosynthesis, when combined with red and blue (peaks at 453 and 638 nm) or warm white (peaks at 453 and 599 nm) LED light with a photosynthetic photon flux density (PPFD) of 50
to 750 μmol·m$^{-2}$·s$^{-1}$. The quantum efficiency of photosystem II ($\Phi_{\text{PSII}}$) increased within 10–15 s after adding far-red light, with an average increase of 6% to 7% under red/blue and 3% to 4% under warm white LEDs. Similar or greater increases in $\Phi_{\text{PSII}}$ were observed 20 min after adding far-red light. This longer-term effect of far-red light on $\Phi_{\text{PSII}}$ was accompanied by a reduction in non-photochemical quenching of chlorophyll fluorescence, indicating that far-red light reduced the dissipation of absorbed light as heat. Net photosynthetic rate (PN) was also enhanced by far-red light: For each 1% increase in PPFD provided by the far-red light, PN increased by an average of 4% and 3% under the red/blue and warm white light, respectively. Under shorter wavelength light (< 680 nm), photosystem I (PSI) tends to be under-excited relative to PSII. As light with wavelengths > 680 nm largely excites PSI, but not PSII, the addition of far-red light may enhance photosynthesis by balancing the excitation energy between the two photosystems and ensure that they operate at matching rates. Our findings suggest that adding far-red light to lighting sources containing little or no far-red can improve the efficiency of photosynthetic lighting over a wide range of light intensities.

**Oral Session—Nursery Crops 2**

**Moderator:** Jacob Shreckhise  
Virginia Polytechnic Institute & State University, Virginia Beach, VA

8:00–8:15 AM

**Biochar Affects Nutrient Leaching from Container-grown Woody Plants with Different Water Requirements**

Nastaran Basiri Jahromi*  
University of Tennessee, Knoxville

Forbes Walker  
University of Tennessee, Knoxville

Amy Fulcher  
University of Tennessee, Knoxville, TN

James Allland  
USDA-ARS, MWA ATRU, Wooster, OH

A carbon rich by-product of pyrolysis known as biochar has been described as a means to enhance soil nutrient retention. Moreover, it can cause an increase in soil fertility in the long-term by increasing the cation exchange capacity and surface area and also increase water retention, which can reduce nutrient leaching. The objective of this research was to determine the effect of switchgrass biochar on nutrient release and retention when used in a container substrate. *Buxus sempervirens* x *B. microphylla* (*'Green Velvet'* boxwood) and *Hydrangea paniculata* (Pinky Winky® hardy hydrangea) were potted into 1 gallon (3.7 L) containers filled with pine bark and amended with either 10% or 25% (v/v) biochar. Plants were irrigated with a moisture sensor-based irrigation system that provided a prescribed volume of water to plants based on the physical properties of the substrate to determine the impact of biochar on nutrient leaching. Leachate analysis over the course of the 8-week experiment showed that the average mass of phosphate, potassium and total carbon was greater in the leachate from containers that received 25% biochar compared to those receiving 0% or 10% biochar for both plant species. For hydrangea, mass of total nitrogen (TN), nitrate (NO$_3$), and ammonium (NH$_4$) in leachate was not affected by substrate. However, for boxwood, the mass of NO$_3$ and TN were greater for the 25% biochar treatments, while mass of NH$_4$ was not affected by substrate. In hydrangea, the total amount of water leached and nutrients lost from the containers was lower in biochar-amended containers (both 10% and 25% biochar) due to receiving a lower total volume of water. Amendment with biochar was also shown to affect concentration of phosphorus and potassium, increasing concentration with greater biochar amendment, in both leaf tissue and substrate.

*Specified Source(s) of Funding:* USDA-NIFA National Integrated Water Quality Program

8:15–8:30 AM

**Effect of Colored Shade Cloth on the Quality and Yield of Vegetable and Cut Flower in Mississippi**

Tongyin Li*  
Mississippi State University, Mississippi State, MS

Guihong Bi  
Mississippi State University, Mississippi State, MS

Casey Barickman  
Mississippi State University, Verona

William Evans  
Mississippi State University, Crystal Springs

Judson LeCompte  
Mississippi State University, Mississippi State University, MS

Shade cloth has been used to reduce heat stress at locations with high summer temperature. Depending on plant species, chemical compounds as well morphological characteristics, such as plant height, leaf area, and branching can be altered by shade. The influence of three colored shades (red, blue, and black) with 50% shade and a no-shade control on the growth and yield of two lettuce cultivars (green-leaf ‘Two Star’ and red-leaf ‘New Red Fire’), one snapdragon (Red, Potomac Series, Ball Seed), and one sweet basil cultivar was investigated. Results demonstrated that colored shade cloth increased plant growth indices of lettuce compared to the no-shade control. Red shade cloth resulted in higher leaf area than the black and blue shades and higher lettuce fresh weight than all other three treatments. Lettuce grown under the no-shade control had higher stomatal conductance, possibly in response to the higher photosynthetic active radiation. The two lettuce cultivars varied in their flavonoid compounds, with the green-leaf ‘Two Star’ had higher quercetin glucuronide, quercetin glucoside, and caftaric acid than the red-leaf ‘New Red Fire’, whereas ‘New Red Fire’ had higher concentrations of chlorogenic acid, luteolin, and quercetin malonyl. The shade

An asterisk (*) following a name indicates the presenting author.
decreased luteolin and quercetin malonyl concentration for both lettuce cultivars and decreased cyanidin glucoside in the red-leaf ‘New Red Fire’. As for snapdragons, the no-shade control produced the first harvest of flower stems roughly a week earlier than the shade treatments. Shade cloth increased the length of snapdragon flower stems compared to the no-shade control in the first round harvest. In the second round harvest, red shade produced longer flower stems and longer inflorescence of snapdragons than the blue and black shades. Plant growth and yield of basil plants did not vary among shade color.

8:30– 8:45 AM

**Soil-applied Paclobutrazol Controls Shoot Growth of Field- and Container-grown Conifers**

Bert Cregg*
Michigan State University, East Lansing, MI

Brent Crain
Michigan State University, East Lansing, MI

Field-grown and container-grown conifers represent a major portion of the landscape tree market in the Midwestern United States. Growers commonly prune or shear conifers as part of their standard nursery culture. In this project we examined the utility of soil-applied paclobutrazol to control height growth of conifers in a field trial and in a container study. In the field trial, the effectiveness of soil-applied paclobutrazol on height growth varied with species and tree size. Paclobutrazol reduced height growth of field-grown Norway spruce (Picea abies) trees by 50% compared with untreated control trees. Paclobutrazol reduced height growth of small (< 1.3 m tall at treatment) blue spruce (Picea pungens) trees by 52% compared to control trees but did not affect growth of trees in two larger size classes (1.3-1.8 m and >1.8 m). In the container study, soil drench with paclobutrazol did not affect shoot growth of Norway spruce, Serbian spruce (Picea omorika) or white pine (Pinus strobus) in the growing season following treatments but reduced growth the following year. For all species, there was no difference in the height growth between high and low rate of paclobutrazol. This indicates that the low rate was sufficient to achieve height control and suggests that additional research to develop dose-response curves is needed. In addition to growth control, treatment with paclobutrazol indicated in visibly greener plants. Analysis of needle chlorophyll concentration demonstrated that application of paclobutrazol increased needle chlorophyll concentration of Norway spruce and white pine but not Serbian spruce.

*Specified Source(s) of Funding:* We gratefully acknowledge funding from the Michigan Christmas Tree Association. This work was supported by a USDA Specialty Crop Block Grant.

8:45–9:00 AM

**Growth Response of Ilex and Hydrangea using Low-phosphorus Controlled-release Fertilizers**

Jacob Shreckhise*
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Jim Owen
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Alexander Niemiera
Virginia Polytechnic Institute & State University, Blacksburg, VA

Containerized nursery crops require relatively low substrate pore-water phosphorus (P) concentrations (i.e., <5 mg·L⁻¹) to achieve and sustain optimal growth. Industry-standard controlled-release fertilizers (CRFs) may supply higher phosphorus (P) concentrations than what are necessary for optimal growth, resulting in low P use efficiencies (amount of applied P used by the plant) and losses of excess P via leaching. Adopting low-P CRFs could improve crop P use efficiency and assist with compliance of future nutrient environmental regulations. This study was conducted to determine if CRFs with decreased P content can be utilized to sustain optimal growth of two common Virginia nursery crops for ~4 months in over-head irrigated open-air nurseries set in two climatically different Virginia locations: Blacksburg (USDA Hardiness Zone 6b; 104 cm avg. annual rainfall) or Virginia Beach (USDA Hardiness Zone 8a; 122 cm avg. annual rainfall). *Ilex crenata* ‘Thunb. Helleri’ (holly) and *Hydrangea macrophylla* ‘P11HM-11’ Bloomstruck™ (hydrangea) were top-dressed with 20 g of one of four low-P CRFs, each containing 18N–10K and 0.4P, 0.9P, 1.3P, 2.2P or a control (24 g of 16N–2.6P–10K; standard nursery fertilizer); all CRFs were an 8 to 9 month formulation. Average leaching fraction of 0.37 ± 0.06 for holly and 0.59 ± 0.06 for hydrangea were observed. In Blacksburg, holly maximal shoot dry weight (SDW) occurred in plants fertilized with 0.9 P fertilizer or greater. In contrast, maximal SDW for holly growing in Virginia Beach occurred when fertilized with the 2.2 P fertilizer, indicating intra-taxa variability in P requirement depending on geographical location. In both locations, hydrangea SDW was highest when fertilized with the control or treatments containing at least 1.3 P. Thus, data indicates that P in CRF may be reduced by as much as 50% without reducing plant growth for *Hydrangea macrophylla*. However, additional research is needed to ensure low-P fertilizers are suitable for a variety of plant taxa and across a wider range of geographic locations.

*Specified Source(s) of Funding:* Funded in part by Horticultural Research Institute, Virginia Agricultural Council, and Virginia Agricultural Experiment Station and the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture.

9:00–9:15 AM

**Improving Water and Nutrient Retention Capacity of the Pine Bark Substrate Using Amendments**

Krishna Nemali*
Purdue University, West Lafayette

Marc van Iersel
University of Georgia, Athens, GA

Significant amounts of water and nutrients are leached from the
Oral Presentations

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

Matthew Kleinhenz
The Ohio State University-OARDC, Wooster, OH

The use of grafted plants to limit biotic and abiotic stress, extend production-market windows, and increase productivity is becoming more common worldwide. Still, it is important to verify that grafting does not result in deleterious changes in fruit quality through, for example, unwanted shifts in shoot physiology or the translocation of unwanted substances from root to shoot. Given the origin, makeup, and history of some rootstocks, careful rootstock-scion evaluation and selection and grafted plant management may be needed. The objective of this study was to document the effects of grafting and rootstock-scion combination on major fruit physical and chemical characteristics. Four pepper scions: a) two blocky varieties (‘Toronto’—yellow and ‘Zedinca’—red) and b) two elongated varieties (‘Kurtovszka Kápiá’ and ‘Eigman’) were splice-grafted onto five rootstocks (‘TAN TAN (NO: 12G076)’, ‘52-03 RZ’, ‘Budai csipős’, ‘NOURDINE’, and ‘CCA-4758’) varying in fruit shape, size, and other traits. Additionally, the four scion varieties were self-grafted and non-grafted as controls. Plants representing all rootstock-scion combinations and controls were arranged in a randomized complete block design with three replicates, pruned according to local practice, and grown in a passively-controlled, plastic-covered greenhouse in Kafr El-Sheikh, Egypt. All fruits were harvested when fully mature and three to five fruits per plant were randomly selected for further measurement (length, diameter, shape index, flesh thickness, soluble solids content, ascorbic acid content, and total titratable acidity). The experiment was repeated in June 2013–May 2014 and June 2014–May 2015. Fruit yield, size, and thickness were larger and values of fruit chemical attributes tended to be greater in grafted than in ungrafted plants. Grafting onto rootstocks also tended to produce larger and thicker fruit with higher chemical attribute values (except titratable acidity) relative to fruit from self- and ungrafted control plants. For example, self-grafted ‘Toronto’ produced fruit with flesh thickness 5.6% higher and soluble solids content 16.6% higher compared to non-grafted plants. Overall, fruit thickness of all rootstock-scion combinations ranged from 0% to 22.4% higher in grafted than non-grafted plants whereas soluble solids content ranged from 22.9% to 35.1% higher in grafted than non-grafted plants.

An oral presentation on the effects of grafting and rootstock-scion combinations on pepper fruit quality was given by Matthew Kleinhenz. The study found that grafting and rootstock selection had a significant impact on fruit yield, size, and chemical attributes, with grafted plants generally showing higher values compared to non-grafted controls. The research was conducted in a plastic-covered greenhouse in Kafr El-Sheikh, Egypt, and involved five pepper scions and five rootstocks, with both self-grafted and non-grafted controls. The experiment was repeated over two seasons to account for variability in environmental conditions.

Oral Session—Vegetable Crops

Management 2

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

8:00–8:15 AM

Granting and Rootstock Effects on Pepper (Capsicum annuum L.) Fruit Morphological and Chemical Characteristics Grown Under Plastic House Conditions

Mahmoud Mohammad Ahmed Soltan*
The Ohio State University-OARDC, Wooster, OH

Farouk Abd El-Salam El-Aidy
Kafir El-Sheikh University-Faculty of Agriculture, Kafr El-Sheikh, Egypt

Mohamed Bassiouny El-Sawy
Kafir El-Sheikh University-Faculty of Agriculture, Kafr El-Sheikh, Egypt

Sami Abd El-Gwaad Gaafar
Agriculture Research Center-Horticulture Research Institute, Giza, Egypt

The objective of the study is to assess the effect of amending a standard nursery substrate (8 parts pine bark + 1 part sand, PBS) with either calcined clay (PBSC) or diatomaceous earth (PBSD) at 10% v/v to improve water and nutrient retention. Measurements included soil moisture retention (SMR) curves for each substrate, and electrical conductivity (EC) and nitrate concentration of each substrate after sequential irrigations. The SMR curves indicated that container capacity of PBS substrate was lower than that of the PBSC substrate but not different to the PBSD substrate. This indicates that water retention capacity of PBS substrate can be improved by amending with calcined clay. Approximately 10%, 28%, and 38% of water drained as the water potential dropped from container capacity to –1.0 MPa (close to wilting point) in PBS, PBSD and PBSC substrates respectively. This indicates that more water can be available to plants when PBS substrate is amended with either diatomaceous earth or calcined clay. Moreover, amending PBS substrate with diatomaceous earth or calcined clay could decrease the risk of rapid exposure of plants to drought stress that may happen in PBS substrate. Although EC and nitrate concentration of all three substrates decreased during sequential irrigations, both measures remained higher for PBSC and PBSD than PBS substrate after any irrigation. This indicates that nutrient retention in general, and nitrate retention, in particular was improved by amending PBS with calcined clay. Approximately 10%,

Comparative Analysis of Tomato Rootstock Root System Morphology

David Suchoff*
North Carolina State University, Raleigh, NC

Christopher Gunter
North Carolina State University, Raleigh, NC

At its most basic, grafting is the replacement of one root system with another containing more desirable traits. Grafting of tomato (Solanum lycopersicum) onto disease-resistant rootstocks is an increasingly popular alternative to managing economically damaging soil-borne diseases. Certain rootstocks have been

8:15–8:30 AM

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shown to confer additional benefits to the scion in the form of improved tolerance to edaphic and other abiotic stresses; however, the mechanisms behind the enhanced stress tolerance are not well understood. Specific traits within root system morphology (RSM), in both field crops and vegetables, have been shown to improve growth under abiotic stress conditions. A greenhouse study was conducted November 2015–January 2016 to compare the RSM of 17 commercially available tomato rootstocks and one commercial field variety (‘Florida-47’). Plants were grown in containers filled with a mixture of Turface® and pool filter sand (2:1 v/v) and harvested at 2-, 3-, or 4-weeks after emergence. The study was laid out in a RCBD with four blocks and a fully factorial (18 cultigens 3 harvest dates) arrangement. At harvest, roots were carefully cleaned and then stained with 0.5 g·L⁻¹ neutral red dye for 24 h. Following staining, roots were scanned and analyzed with WinRhizo. Data collected included total root length (TRL), average root diameter, specific root length (SRL), and relative diameter class. No significant cultigen harvest interaction was found. The main effect of cultigen was significant (P ≤ 0.05) for all response variables and the main effect of harvest was only significant (P ≤ 0.01) for TRL. ‘Shield RZ’, ‘RST-106’, and ‘TD-2’ had the longest TRL throughout whereas ‘Beaufort’, ‘Kaiser’, and ‘RST-105’ had the shortest. ‘BHN-1088’ had the thickest average root diameter, which was 32% thicker than the thinnest, observed in ‘Beaufort’. SRL in ‘Beaufort’ was 60% larger than ‘BHN-1088’. This study demonstrated that, in the non-grafted state, differences exist in RSM of tomato rootstocks grown and that, grown in a solid porous media, these differences can be quantified quickly and accurately using WinRhizo software. This method has the potential to help serve as a screen to further characterize rootstock quality and selection for growers.

8:30–8:45 AM

**Effect of Fertilizer Source and Grafting on Tomato Growth, Leaf Nitrogen, and Fruit Yield in High Tunnels**

Fairuz Buajaila*
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Jeremy Cowan
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Washington State University, Pullman, WA

Debra A. Inglis
Washington State University, Mount Vernon, WA

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Washington State University, NWREC, Mount Vernon, WA

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

This study investigates fertilizer source and the use of grafted plants for season extension and fruit yield of tomato grown in high tunnels in northwest Washington in 2015. An integrated fertilizer [poultry manure (2242 kg·ha⁻¹) plus 90 kg·ha⁻¹ urea (46–0–0)] was compared with commercial chemical fertilizer [monoammonium phosphate (11-52-0), potassium sulfate (0-0-50), and urea (46–0–0)] applied at 112 N, 168 P₂O₅, and 56 K₂O kg·ha⁻¹, and plant growth and fruit yield were measured. Additionally, grafting was tested to see if it affects leaf petiole nitrogen, early marketable yield, and season extension. Grafting treatments were ‘Panzer’ tomato grafted on ‘Estamino’, ‘Maxifort’, ‘DRO138TX’, and non-grafted ‘Panzer’ (control). Plant height and number of leaves were measured at transplanting and every 3 weeks thereafter. Height was greater for plants grown with commercial fertilizer than with integrated fertility on 21 May and 11 June, but there was no effect due to grafting with the three rootstocks. Plants grown with commercial fertilizer had more leaves than plants grown with integrated fertility on 30 Apr., 21 May, and 11 June, but there was no difference among the three rootstocks. Plants were pruned once per week from 30 Apr. to 24 Aug., and pruning biomass was greater with commercial fertilizer than for the integrated fertility treatment early in the season (4 and 11 June), and due to rootstocks later in the season (21 July, 10 and 24 Aug.). Nitrate-N was measured in both leaf tissue and fresh petiole sap of fifth or sixth youngest fully mature leaf (from the plant top) at 5, 7, 9, and 11 weeks after transplanting. There was no effect of fertilizer source on nitrate-N of either leaf tissue or fresh petiole sap; however, plants grafted on ‘Estamino’ had significantly more nitrate-N in fresh petiole sap on 1 June. Fruit were harvested once a week at 75% red stage, and harvest did not occur significantly earlier or later in the high tunnel due to the use of grafted plants. Marketable fruit number was greater for non-grafted plants on 21 July, for plants grafted with ‘Estamino’ on 14 Sept., and with the integrated fertility treatment on 28 Sept. Total mean marketable fruit weight was 6.3 kg per plant and did not differ due to fertilizer source or rootstock. Fertility management with 100% mineral fertilizer or an integrated fertility treatment can have equal fruit yield, and grafting did not affect harvest window or yield.

*Specified Source(s) of Funding: the Libyan government

8:45–9:00 AM

**Grafting, Irrigation, and Fertilization Effects on Tomato Plant Growth and Fruit Yield and Quality**

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The Ohio State University-OARDC, Wooster, OH

Jennifer Moyseenko
The Ohio State University-OARDC, Wooster, OH

Matthew Kleinhizen
The Ohio State University-OARDC, Wooster, OH

The use of grafted vegetable plants is expanding in the United States, partly because of reports that they withstand biotic and abiotic stresses more effectively than standard, ungrafted seedlings. However, it is still unclear whether this capacity extends across sites, growing conditions, and rootstock-scion combinations. Our objective was to test the effects of irrigation and fertilization regimes and grafting on tomato growth, and
fruit yield and quality in conventionally managed field plots. Studies were conducted in 4 years as a split-plot design with irrigation (2012) or fertilization management (2013–15) as the main plot and grafting as the subplot. Two irrigation treatments (standard, 50% of standard) were tested in 2012. Two fertilization treatments (pre-plant fertilization only, pre-plant fertilization plus standard fertigation) were tested in 2013 and 2014; and, four fertilization treatments (no pre-plant fertilization, pre-plant fertilization only, pre-plant fertilization plus standard fertigation, pre-plant fertilization with 150% of standard fertigation) were employed in 2015. Two commercial rootstocks (‘Maxifort’ and ‘Emperor’) and one experimental line (‘320’) were used in 2012 to 2014. Three commercial rootstocks (‘Maxifort’, ‘Estamino’ and ‘Supernatural’) were included in 2015. ‘BHN589’ was used as the scion and ungrafted control each year. Ripe fruits were harvested weekly 7, 7, 5, and 4 times in 2012, 2013, 2014, and 2015, respectively. Total and marketable fruit weight and number were measured, and average marketable fruit weight and marketable yield percentage were calculated. A subset of fruits was analyzed for fruit quality including Brix, pH, and titratable acidity (TA). In 2013 and 2014, plant growth was also monitored. Above-ground vegetative biomass, leaf area and N content, and truss number were greater in grafted than ungrafted plants in 2013, but the opposite was true in 2014. Regardless, yield trends were consistent across all years, with grafted plants having greater total seasonal yield than ungrafted plants. Neither irrigation nor fertilization management affected yield in 2012 and 2013, but fertilization affected yield in 2014 and 2015. The Brix was higher in fruits from ungrafted versus grafted plants across all years. Fruit pH and TA were greater at the higher fertilization rate in 2014 and 2015. The Brix of fruits from grafted plants was affected by fertilization treatments. Lower Brix was observed in grafted plants, across all in-row spacings, with significant effects on marketable yield and yield increase. Grafting and in-row spacing showed significant effects on fruit yield. Despite higher root-knot nematode galling ratings in grafted plants, across all in-row spacings, grafting significantly improved marketable fruit number and average fruit weight on both per-plant and per-acre bases. With respect to in-row spacing, both marketable fruit number and weight per plant were highest at 1.68 m spacing while they were highest on a per-acre basis at 1.07 m spacing. At the first harvest, fruit quality analysis showed some differences in lycopene (non-grafted ‘Melody’ watermelon at 0.76 m spacing had the highest value) and lightness of fresh color (non-grafted ‘Melody’ watermelon at 1.68 m spacing had the lowest value). Interestingly, grafting significantly reduced hollow heart incidence at the second harvest.

Specified Source(s) of Funding: USDA-SCRI

9:00–9:15 AM

Grafted Seedless Watermelon Production with Different Planting Densities

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Zack Black
University of Florida, Gainesville, FL

Jeffrey Brecht
University of Florida/IFAS, Gainesville, FL

Charles Sims
University of Florida, Gainesville, FL

Grafting watermelon with hybrid squash rootstocks can provide resistance to certain soil-borne diseases and improve plant vigor, thus leading to enhanced fruit yield. Given the yield improvement of grafted plants, the potential of reducing grafted plant population to increase cost effectiveness was explored. This study was designed to assess rootstock effects on yield and fruit quality of seedless watermelon grown with different in-row planting densities. The field trial was carried out in Fall 2015 in Citra, FL., with seedless watermelon (Citrullus lanatus) ‘Melody’ grafted onto interspecific squash (Cucurbita maxima x C. moschata) hybrid rootstock ‘Super Shintosa’. Grafted and non-grafted ‘Melody’ were planted using in-row spacings of 0.76, 1.07, 1.37, and 1.68 m, with a constant between-row spacing of 2.44 m, resulting in populations ranging from 2444 to 5378 plants/ha. The experiment was arranged in a split-plot design with four replications, with planting densities as the whole plot treatments and grafting as the subplot factor. Marketable and unmarketable fruit weight and number were recorded for two harvests. At the first harvest, six fully ripe fruit from grafted and non-grafted plants in the 0.76 and 1.68 m treatments were sampled and stored overnight at 12 °C before fruit quality assessment. Instrumental measurements included flesh firmness, total soluble solids, titratable acidity, pH, flesh color, and lycopene content. Overall acceptability, flavor, and firmness were evaluated by consumer sensory analysis using a 1–9 hedonic scale, while sweetness, firmness, and juiciness were scored using a 1-5 “just about right” scale. At the second harvest, all the fruit were cut for evaluation of hollow heart. After the final harvest, plant roots were scored for root-knot nematode galling using a 0–10 rating scale. Grafting and in-row spacing showed significant effects on fruit yield. Despite higher root-knot nematode galling ratings in grafted plants, across all in-row spacings, grafting significantly improved marketable fruit number and average fruit weight on both per-plant and per-acre bases. With respect to in-row spacing, both marketable fruit number and weight per plant were highest at 1.68 m spacing while they were highest on a per-acre basis at 1.07 m spacing. At the first harvest, fruit quality analysis showed some differences in lycopene (non-grafted ‘Melody’ watermelon at 0.76 m spacing had the highest value) and lightness of fresh color (non-grafted ‘Melody’ watermelon at 1.68 m spacing had the lowest value). Interestingly, grafting significantly reduced hollow heart incidence at the second harvest.

Specified Source(s) of Funding: FDACS

9:15–9:30 AM

Grafting Watermelon to Control Verticillium Wilt Caused By Verticillium dahliae in Washington

Sahar Dabiran*
Washington State University, Mount Vernon, WA

Verticillium wilt, caused by the soilborne fungus Verticillium dahliae, is a significant disease affecting watermelon production in Washington State. In 2015, a field study was conducted at three locations in Washington to investigate the Verticillium wilt reactions, and fruit yield and quality of watermelon cv. TriX Palomar non-grafted (control) and grafted with rootstocks Super Shintosa, Tetsukabuto and Just grown with black and clear
plastic mulch. At planting, soil in each main plot had less than 1 cfu·g⁻¹ of soil *V. dahliae* at Eltopia and Othello and 28 cfu·g⁻¹ of soil at Mount Vernon. After harvest *V. dahliae* soil density under black mulch increased to 4, 4.5, and 55 cfu·g⁻¹ of soil at Eltopia, Othello, and Mount Vernon, respectively. In contrast, *V. dahliae* under clear mulch was similar to the level at planting at each location (< 1, 2.6, and 27 cfu·g⁻¹ of soil, respectively). Area under disease progress curve (AUDPC) values differed significantly among treatments at all locations. AUDPC was greater for plants grown with black mulch (385) than for plants grown with clear mulch (237). AUDPC was greatest at Mount Vernon (680), and lowest at Eltopia (71). And AUDPC was greater for non-grafted TriX Palomar (707) than for grafted TriX Palomar (average 201). There was a significant interaction between location and rootstock for fruit yield per plant. At Mount Vernon, where Verticillium wilt pressure was highest, yield of non-grafted TriX Palomar was lower (7.4 kg/plant) than grafted treatments (average 13.0 kg/plant). At Othello and Eltopia, there was no significant difference in yield due to grafting. At season’s end, *V. dahliae* presence in stems, was greatest for non-grafted TriX Palomar at Mount Vernon and Eltopia (87.50 and 89.06, respectively), and there was no difference at Othello (average 22.67). Fruit firmness was greater at Mount Vernon (3.00 N) than Othello and Eltopia (2.44 and 2.20 N, respectively) and was lower for non-grafted TriX Palomar (2.20 N) than for all 3 grafted treatments (average 2.67 N). Additionally, fruit firmness was greater for TriX Palomar grafted onto Tetsukabuto grown with black mulch; however there was no difference for fruit grown with clear mulch. At Mount Vernon TSS (%) was greater for non-grafted TriX Palomar (11.04%) and lowest for TriX Palomar grafted to Tetsukabuto and Super Shintosa (10.25% and 10.27%, respectively). There was no significant difference in TSS at Othello (average 10.58%) or Eltopia (average 10.28%).

**Specified Source(s) of Funding:** WSDA (SCBG) and USDA (NIFA SCRI)

**Oral Session—Postharvest 3**

*Moderator:* Jacqueline Nock  
Cornell University, Ithaca, NY

8:00–8:15 AM

**Browning Disorders and DA Meter Readings in ‘Gala’ Apples**

Nurdan Gunes*  
School of Integrative Plant Science, Horticulture Section, Cornell University, Ithaca, NY

Jacqueline Nock  
School of Integrative Plant Science, Horticulture Section, Cornell University, Ithaca, NY

Yosef Al-Shoffe  
School of Integrative Plant Science, Horticulture Section, Cornell University, Ithaca, NY

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Consumer demand for ‘Gala’ [*Malus sylvestris* (L.) Mill var. *domestica* (Borkh.) Mansf.] is high thanks to its desirable texture and flavor characteristics. Increasingly, however, stem end browning (SEB), senescent breakdown and core browning has been found in stored fruit. As a result, fresh cut and whole fruit sales are affected and significant economic losses have occurred. We have investigated the effects of fruit maturity, storage temperature and conditioning on quality of controlled atmosphere (CA) stored fruit. The Delta Absorbance (DA) meter was used to categorize fruit into 7 different IAOD classes at harvest. Fruit were stored in CA storage (2% O₂ + 2% CO₂) at either 0.5 °C or 3 °C directly or after one week of conditioning at 10 °C. Internal ethylene concentrations, soluble solid concentrations and starch pattern indices increased as IAOD values decreased (less chlorophyll), but flesh firmness or titratable acidity were not affected by maturity. After 6 months of storage, SEB incidence and severity was not affected by conditioning, but was higher in lower IAOD classes in 0.5 °C, and in higher IAOD classes in 3 °C. Senescent breakdown was higher in the lower IAOD classes and higher storage temperature. Core browning was observed only in fruit from the 0 IAOD class at 3 °C with conditioning. Greasiness was greater in the lower IAOD classes, the higher storage temperature, and with the addition of a conditioning treatment. Separation of maturity using IAOD classes is a valuable method to investigate variation of responses within a population of fruit.

**Specified Source(s) of Funding:** We thank the NY Apple Research and Development Program and the USDA National Institute of Food and Agriculture, Hatch project 2013-14-483, Non-destructive Measurement of Apple Maturity (NE-1336) for their support. Y. Al Shoffe was supported in part by . . .

8:15–8:30 AM

**Controlled Atmosphere (CA) and Dynamic CA-Chlorophyll Fluorescence (DCA-CF) Storage of ‘Gala’ Apple**

Jacqueline Nock*  
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An asterisk (*) following a name indicates the presenting author.
Stem end browning (SEB) in ‘Gala’ is becoming a significant problem for storage operators as volumes of fruit and hence storage periods are increasing. In this study we have investigated the effects of air, CA and DCA-Chlorophyll Fluorescence as well as the use of 1-methylcyclopropene on SEB incidence and severity taking two approaches. In the first, ‘Gala’ trees in a western NY orchard were either untreated or treated with the preharvest plant growth regulator Harvista™ (1-methylcyclopropene; 1-MCP) 1 week prior to the first harvest, spot picked for color early in the harvest window and then strip picked the following week. Fruit were cooled to 0.5 °C overnight and then either treated or not with SmartFresh (1-methylcyclopropene; 1-MCP) and kept in air, CA or DCA-CF (harvest 1 only) for up to 6 months. In the second, fruit were obtained from four orchards and stored in CA and DCA-CF after half of the fruit were treated with SmartFresh. In both experiments, O2 partial pressures were kept 0.2 kPa above the fluorescence-derived low O2 limit of 0.3 kPa, plus 1 kPa CO2, while CA conditions were pressures were kept 0.2 kPa above the fluorescence-derived low O2 limit of 0.3 kPa, plus 1 kPa CO2, while CA conditions were.

The HarvestWatch™ equipment was provided by ACA HandelsgesmbH, Moritschstraße 2/II, 9500 Villach, Österreich/Austria. This work was supported by the USDA National Institute of Food and Agriculture, Hatch.

**Specified Source(s) of Funding:** The HarvestWatch™ equipment was provided by ACA HandelsgesmbH, Moritschstraße 2/II, 9500 Villach, Österreich/Austria. This work was supported by the NY Apple Research and Development Program and the USDA National Institute of Food and Agriculture, Hatch.

8:30–8:45 AM

**Hot Water Treatment and Coatings to Modify Internal Atmosphere of Navel Orange As Determined By Respiration Rate, Gas Exchange, and Sensory Quality**

M.G. Chowdhury*
University of Florida, Gainesville, FL

**Peach Quality: Lexicon Development for Sensory Descriptive Quality Assessment of Fresh Peaches**

Catherine Belisle*
University of Georgia, Athens, GA

**Respiratory activity is important for plant metabolic processes and increases as plants respond to stress. Upregulation of the plant antioxidant system in response to stress increases resistance to subsequent stress exposure. When submerged in heated water, fruit respiration can increase substantially with minimal gas exchange possible, potentially creating extreme internal modified atmospheres (MA) that may also be perceived by the tissues as a stress. Coatings applied to citrus fruits may also create internal MA during storage. The purpose of this research was to select the optimum hot water treatment (HWT) temperature and duration plus fruit coatings in order to create beneficial internal MA for maintaining postharvest quality of fruit stored at 25 ºC. Naval orange (Citrus sinensis) fruit harvested at commercial maturity in January 2016 were dipped for 30 seconds in 1000 ppm thiabendazole. Respiration rates were measured at from 25 ºC to 60 ºC in 5 ºC increments. A data logger recorded the time and temperature when peel and center fruit temperatures were equilibrated and GC was then used to measure respiration rate and internal atmosphere. The maximum respiration rate (200.31 mL CO2/kg-h) occurred at 55 ºC with lower rates at lower and higher temperatures. Different HWTs were evaluated with temperatures from 25 ºC to 55 ºC in 5 ºC increments and durations from 10 to 80 min. Those treatments resulted in internal O2 from 1% to 20% and CO2 from 1% to 30%. Immersion in 45 ºC water for 30 min resulted in the most extreme internal atmosphere (~3% O2 and ~18% CO2) without causing any detrimental effect on external peel appearance. Polyethylene-, carnauba-, or shellac-based coatings were applied to hot-water-treated fruit using a centrifugal applicator on a semi-commercial citrus packing line in order to create possibly beneficial MA within fruit during storage at 25 ºC with 85% RH. Considering the flavor and overall quality of the fruit, consumers ranked fruit with carnauba-based coatings higher than the other treatments, while shellac-coated fruit received the lowest ratings. This was likely due to the internal MA in the fruit, with carnauba resulting in an apparently beneficial atmosphere of ~10% O2 and ~8% CO2 while shellac resulted in more extreme ~5% O2, ~18% CO2 shellac also resulted in elevated ethylene (2–3 ppm), which suggests that injury occurred. Therefore, it can be concluded that HWT followed by application of semipermeable coatings can be used to create and maintain beneficial internal MA in citrus fruits to better maintain fruit quality during storage at ambient temperature.
The reduction in fresh peach consumption per capita has frequently been associated with consumer disapproval of peach quality. The assessment of peach quality, generally has been measured by instrumental methods and/or sensory evaluation. To comparably evaluate these methods, a multistep approach is being tested to measure peach quality with qualitative and quantitative analyses. The objective of this study was to develop a comprehensive lexicon that allows standardization of sensory descriptive testing for peach quality. A lexicon is a standardized vocabulary consisting of terms, definitions, and references used to describe attributes of products. Information can then be tested for correlation among instrumental values for development of a quality index. Fifty-two commercially grown peach varieties in Georgia were selected to represent the widespread variation in cultivars grown in the United States. Six trained panelists were selected to establish terms with definitions and references over a 9-week period, from May to August 2015. Commercially ripe peaches were harvested and maintained in a refrigerated room (5 ± 2°C) for 4–5 days, followed by 2 days at room temperature (21 ± 1°C) and individually given to panelists. Each cultivar was evaluated for attributes of appearance, aromas, textures, flavors, and basic tastes. Attributes were defined and referenced on a 0 to 150-point scale for no presence to highly present. Forty-five attributes were developed with 12 aromas, 13 textures and feeling factors, and 12 flavor attributes. Additional attributes include three basic tastes, four aftertastes, and blush of flesh for appearance. Major terms within peach texture included crispness, juiciness, melting, and fibrousness, these terms appeared in 10, 13, 13, and 16 genotypes in a subsample of 25 peach varieties, respectively. These terms represent the major classification of peach flesh type in melting and non-melting varieties. Unique attributes, such as aromas of apple, citrus, and fruity were found in 2, 3, and 4 genotypes in a subsample of 25 cultivars, respectively. Sensory descriptive and consumer tests and instrumental quality testing (texture evaluation, sugar/acid testing, and volatile analyses) can provide the information necessary to develop a quality index for growers and researchers in peach production to improve market value.

**Peach Quality: Determination of Physical and Chemical Attributes for Quality Evaluation of Fresh Peaches**

Catherine Belisle*
University of Georgia, Athens, GA
Koushik Adhikari
University of Georgia, Griffin, GA
Dario J. Chavez
University of Georgia, Griffin, GA

Quality is a major driver of fruit consumption. In peach quality, attributes of appearance, sugar and acid content, and texture/firmness have generally been assessed. The use of these parameters can help to better understand and differentiate the complexity of peach varieties taste and consumer eating experience. These parameters will help growers to classify the different peach cultivars grown. Fifty varieties of commercially ripe fruit were harvested and stored in a cool room for 5–7 days at (5 ± 2°C), followed by 2–3 days at room temperature (21 ± 1°C). Individual sugar and acids were analyzed for the different varieties using HPLC in the Agricultural and Environmental Services Laboratories at the University of Georgia, Athens, GA. "Brix, total titratable acidity (TTA), texture (puncture, compression and Kramer), and colorimeter values were measured at the University of Georgia, Griffin Campus, Griffin, GA. Statistical significance differences between varieties were observed for all the quality parameters being evaluated (P < 0.05). Among varieties, fruit texture measurements of compression, puncture, and Kramer shear tests, were strongly associated with peach flesh type. A higher firmness force (kgf) was found in non-melting peach varieties and a low firmness force (kgf) in melting varieties. ‘Springprince’, a non-melting clingstone peach, was found to have the highest firmness among all texture tests. Puncture values ranged from 1.69 kgf in ‘Springprince’ to 0.19 kgf in ‘All-Star’, a melting freestone peach. Compression values ranged from 11.60 kgf in ‘Springprince’ to 0.38 kgf in ‘Goldprince’, a melting clingstone peach. Kramer values ranged from 2.03 kgf per gram in ‘Springprince’ to 0.19 kgf per gram in ‘All-Star.’ Among varieties, “Brix values ranged from 7.8 to 15.6 for ‘Brittney Lane’ and ‘Summerflame’, respectively. Sucrose levels comprised the large percentage of total sugars in comparison with glucose and fructose. The TTA values ranged from 0.18% for ‘May Sweet’ to 1.11% in ‘Flavorich.’ The organic acids commonly found among peach varieties were citric acid, succinic acid, and malic acid. There was no correlation between texture forces and “Brix, TTA, juiciness, or individual sugars and acids. Similarly, juiciness, TTA, and “Brix were not correlated. “Brix was correlated with total sugars (R² = 0.617). TTA was highly correlated with citric acid (R² = 0.757) and slightly correlated with ascorbic acid (R² = 0.265). The results of these analyses will be used to develop an index of peach quality to be used in conjunction with sensory attributes to identify peach characteristics associated with likeness.
The Regulation of Ethylene-responsive SLWRKYS on the Color Change during Tomato Fruit Ripening

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Ling Wang
South China Agricultural University, Guangzhou, China

An asterisk (*) following a name indicates the presenting author.
Pomegranate (*Punica granatum*) has been grown as a fruit crop since ancient time with consumption increasing dramatically in recent times in part due to its health benefits and greater accessibility. Extension of fresh fruit availability is of interest with strategies including extending the harvest season or via storage. Pomegranate fruit undergo important late-developmental changes in physical characteristics, growth, and juice biochemistry. Fruit characteristics can differ markedly in early versus late harvested fruit, which can affect microbial load within the fruit and subsequent postharvest storability. Physicochemical changes in pomegranate fruit were assessed and related to microbial flora. Pomegranate fruit were harvested at different times, ranging from premature to late harvest and whole fruits and aril assessments made which included °Brix, pH, titratable acidity, anthocyanin content, and rind color/water content. Microbial contamination was assessed at different locations within fruit. Implications of physico-chemical changes as they relate to microbial contamination and growth will be discussed.

Specified Source(s) of Funding: Purdue

**Oral Session—Water Utilization and Management**

Moderator: Clive Kaiser  
Oregon State University, Milton-Freewater, OR

8:00–8:15 AM

**Remediating Paclobutrazol from Irrigation Water Using Activated Carbon**

George A. Grant*  
University of Florida, Gainesville, FL

Paul Fisher  
University of Florida, Gainesville, FL

James E. Barrett  
University of Florida, Gainesville, FL

Christopher P. Wilson  
University of Florida, Gainesville, FL

Paclobutrazol is an active ingredient used in plant growth regulators to control plant height. Because this chemical has a half-life of approximately 6 months in water, growers who recirculate irrigation water require a method to reduce the level of this residual chemical to below biologically-active levels. The objective was to evaluate the removal of paclobutrazol from water using granular activated carbon filtration (GAC). A 0.05 mg L⁻¹ paclobutrazol solution was passed through a small-scale, 0.50 to 4.75 mm particle size (8 x 30 mesh) coconut coir GAC system at 6 L/minute. A randomized complete-block design was used with six contact times (0, 12, 24, 36, 47, or 59 seconds), which corresponded to 0, 1.9, 3.7, 5.6, 7.5, or 9.4 L of empty filter housing volume (excluding the carbon). The experimental design was a randomized complete block with three blocks (time periods) and three replicates of each GAC treatment per block (54 replicate solutions total). For bioassays, 15 mL of each GAC-treated solution were then applied to broccoli (*Brassica oleracea* ‘Waltham 29’) seed and begonia (*Begonia xsemperflorens-cultorum* ‘Super Olympia White’) seedlings. Broccoli hypocotyls at 14 days were 103% longer and begonia dry mass was 36% greater when treated with solutions that had a contact time of 59 seconds GAC compared with the 0 seconds GAC treatment. With the highest GAC level, begonia dry mass was the same as for plants treated with a zero paclobutrazol solution. Analysis of paclobutrazol concentration using liquid chromatography-mass spectrometry (LC-MS/MS) found that paclobutrazol concentration decreased by 90% or 99% with a contact time of 12 seconds or 59 seconds GAC, respectively. Overall, this experiment showed that granular activated carbon has the potential to remediate paclobutrazol from irrigation water to below biologically-active concentration.

Specified Source(s) of Funding: CleanWateR3

8:15–8:30 AM

**The Effect of Oxygenation of Water on Dissolved Oxygen Measurements in Irrigation Water and Container Substrate**

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University of Florida, Gainesville, FL

Paul Fisher  
University of Florida, Gainesville, FL

Oxygen injection systems are an option to increase dissolved oxygen (DO) in irrigation water. Two experiments evaluated: 1) the persistence of super-saturated DO in irrigation lines, and 2) the DO level in container substrates irrigated with super-saturated water. An optical oxygen sensor was used to measure DO. In the first factorial experiment, there were two water types [“oxygenated” (26.0 mg L⁻¹) or “ambient” (6.3 mg L⁻¹) tap water], and three water delivery points [a holding tank immediately after the oxygen injector or tap (“source”), after being pumped 4.7 m to an outlet (“hose end”), or through a propagation emitter (“mist nozzle”)]. Water type and delivery point interacted in their effect on DO (*P < 0.0001*). Oxygenated water decreased slightly from the source (26.0 mg L⁻¹) to the hose end (24.6 mg L⁻¹), but decreased greatly to 8.7 mg L⁻¹ at the mist nozzle. Ambient water did not differ between the holding tank (6.3 mg L⁻¹) and hose end (7.0 mg L⁻¹), but increased to 8.7 mg L⁻¹ at the mist nozzle. The DO at the mist nozzle was equal for both water types, and close to saturation (8.9 mg L⁻¹). In a second experiment, two different sized containers (20 cm³ “cells” and 400 cm³ “pots”) were filled with a 60:40 (by volume) peat: perlite substrate and irrigated to container capacity with ambient water. Water type was then poured onto the substrate at 0%, 25%, 50%, 100%, or 200% of container volume. Increasing the applied water volume with ambient water did not affect substrate-DO in either container size. However, at a 1-cm depth in the cells, substrate-oxygen increased from 8.6 mg L⁻¹ to 12.3 mg L⁻¹ (a 46% increase in oxygen) as applied oxygenated water increased from 0 to

An asterisk (*) following a name indicates the presenting author.
200% of container volume. A diminishing returns relationship between substrate-oxygen and applied volume of oxygenated water was observed in both the cells and pots. In the pots, substrate-oxygen increased by 68% and 79% at the 2-cm and 4-cm depths, respectively, as applied oxygenated water volume increased from 0% to 200%. Substrate-oxygen was 1.3 mg·L⁻¹ lower at 4-cm compared with 2-cm depth with ambient water, and 2.3 mg·L⁻¹ lower with oxygenated water. In conclusion, passing irrigation through a mist nozzle caused DO to reach an equilibrium saturated level in irrigation water, regardless of whether oxygen was injected. In the substrate, a large volume of oxygenated water was required to increase DO in the substrate.

**Specified Source(s) of Funding:** Clean WateR3, and SCRI

8:30–8:45 AM

**A Protocol to Estimate Plant Available Water Thresholds from Empirical Soil Moisture Sensor Data**

John Lea-Cox*  
University of Maryland, College Park, MD

Bruk Belayneh  
University of Maryland, College Park, MD

Plant available moisture is typically defined as the difference in volumetric water content (% VWC) between field capacity (FC) and some proportion of soil moisture that corresponds to temporary crop water stress. This is typically defined as a negative soil matric potential; for some sensitive crops, temporary water stress could be experienced at –20 to –30 kPa. However soil matric potential is also influenced by the total water-holding capacity (i.e. FC) of a specific soil or substrate type. For example, this is typically much lower for sandy soils than for silt loams. Furthermore, comparing soil matric potential to soil volumetric water content values is very difficult, especially for growers. We will describe a protocol where field capacity can be determined from soil water content curves after a saturating rainfall or irrigation event; the point of inflection of the curve typically between 4 and 8 hours after irrigation. Readily available soil moisture (RAW, defined as –8 to –40 kPa) can be estimated for a range of different soil types and used to calculate the proportion of RAW as a function of total soil moisture (FC). These readily available water ranges can then be confirmed by in situ soil matric potential or leaf water potential measurements throughout the growing season. In this way, threshold values for % VWC can be entered to the graphical software, to provide a quick visual guide for growers to more accurately schedule irrigation events.

**Specified Source(s) of Funding:** USDA-NIFA SCRI Award #2009-51181-05768

8:45–9:00 AM

**Yield and Growth Response of Strawberry (Fragaria xananassa) to Deficit Irrigation**

Bruk Belayneh*  
University of Maryland, College Park, MD

John Lea-Cox  
University of Maryland, College Park, MD

A field experiment was conducted at the University of Maryland Wye REC during 2014–15 to study the effect of deficit irrigation (DI) on strawberry (Fragaria xananassa) growth, yield and yield parameters, and water use efficiency. The randomized complete-block design experiment had four replications, 0.8 m wide x 6.1 m long plots, and 1.5 m spacing between the raised bed centers. Plugs of strawberry cv. Chandler were planted in two staggered rows with 0.3 m spacing between and within rows. Irrigation treatments were based on soil matric potential (SMP) values established for a control (–30 kPa) and three DI treatments (–40 kPa, –50 kPa and –60 kPa). Corresponding volumetric water content (VWC) values were obtained from soil water retention curves developed for the study site using a Hyprop apparatus (UMS, Germany). The VWC values were used as threshold/set-points to trigger irrigation events when the average VWC from two 10HS soil moisture sensors (Decagon Devices, Inc., Pullman, WA) placed in the root-zone of plants in each plot was lower. Treatments were implemented via a wireless sensor network consisting of nR5-DC control nodes (Decagon Devices, Inc.) and irrigation volumes for each plot were also measured using flow meters (Badger Meters, Milwaukee, WI). Deficit irrigation treatments significantly reduced water applications. Significant yield reductions were observed for deficit irrigation treatments due to reduced number of fruits per plant. There were no differences in average fruit weight and irrigation water use efficiency between treatments. The results indicated the sensitivity of strawberry plants to changes in plant available water within the relatively narrow SMP range imposed in the study. The study is being repeated during 2015-16, using T8 field tensiometers (UMS) to further validate SMP levels imposed in the treatments and to accurately quantify plant available water in the control and DI treatments. Understanding responses of strawberry plants to changes in soil water status is essential to identify DI strategies to improve irrigation water use-efficiency and reduce potential nutrient leaching from strawberry production.

**Specified Source(s) of Funding:** This project is funded by a grant from the Walmart Foundation and administered by the University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability

9:00–9:15 AM

**Water Savings upon Conversion from Seepage to Sprinkler Overhead Irrigation for Potato Production: A Three-year On-farm Study**

David Liu*  
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University of Florida, Gainesville, FL

Yuqi Cui  
University of Florida, Gainesville, FL

An asterisk (*) following a name indicates the presenting author.
This three-year study evaluated water savings by converting seepage to sprinkler-overhead for commercial potato production. This study was conducted on a private farm with 526 ha (1300 acres) grown ‘Atlantic’ and ‘Red LaSoda’ in three consecutive growing seasons from 2012 to 2015. Two irrigation treatments were used: seepage and sprinkler-overhead (center-pivot) irrigation with four replications. Plot size was 405 m² (0.1 acres). Water usage, water table level, soil moisture, leaf water potential, leaf greenness, tuber yield and quality were evaluated. There were significant reductions of 57.5% in water usage with sprinkler irrigation as compared to seepage. The reduction in water usage on the farm was 1.50, 1.41, and 0.78 million m³ as compared to seepage. The reduction in water usage was 10% greater in both yields and N use efficiency than sprinkler-overhead irrigation. Further adjustments in the timing of fertilizer application might be required for sprinkler overhead irrigation. Fertigation might be a viable option for sprinkler overhead irrigation for potato production.

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

9:15–9:30 AM

**Trees in Pavement: Modelling Water and Heat Flux in Street Tree Plantings Using HYDRUS**

Francisco Javier de la Mota Daniel*
Virginia Polytechnic Institute & State University, Blacksburg, VA

Susan D. Day
Virginia Polytechnic Institute & State University, Blacksburg, VA

Jim Owen
Virginia Polytechnic Institute & State University, Blacksburg, VA

Ryan D. Stewart
Virginia Polytechnic Institute & State University, Blacksburg, VA

Street trees are an important mediator of water and heat fluxes in urban environments. Pervious pavement is increasingly being installed as an alternative to mulch or bare soil around urban trees in paved areas to create level walking surfaces while allowing infiltration of storm water. However, it is unknown how these new surface materials influence water and heat fluxes and the subsequent effect on tree health. We address this question by using experimental observations of root distribution, tree growth, soil water and temperature, and tree water uptake, to calibrate a numerical modelling environment, HYDRUS-1D. This model simulates water, heat, and solute movement in agricultural soils, but has not been used with the engineered layers common in urban systems. We evaluated the ability of HYDRUS to estimate root depth distribution in response to these layered pavement/soil profiles. We hypothesize that 1) HYDRUS-1D can be further calibrated to predict water and heat fluxes in engineered urban soil systems that include pervious pavement, a gravel base course, and geotextile layers; and 2) upper soil layers under pervious pavement will have greater water content, resulting in shallower root systems, compared to those in bare soil. To generate the observational data, in November 2014 we built 24 simulated urban tree pits, half of which were covered with pervious pavement, comprising a non-woven geotextile, base course and resin-bound gravel. We planted *Platanus x acerifolia* ‘Bloodgood’ whips in 12 of the 24 pits resulting in 4 treatments: tree-pavement, no tree-pavement, tree-soil, no tree-soil. We measured saturated hydraulic conductivity, texture, pore size distribution, and bulk density at 10- and 60-cm depths. We recorded stem diameter and root distribution and continuously monitored soil moisture and temperature at different intervals throughout the year. These values, together with layer thickness and the hydraulic conductivity of the geotextile, base course and pervious pavement, were used to characterize the behavior of each layer in HYDRUS-1D. After one growing season, trees in pavement had 59% greater stem diameters than those in bare soil and more superficial root systems. Root distribution was associated with greater soil moisture, suggesting that a root growth model is possible. Results have implications for pavement section design to increase street tree resilience to climate change as well as to reduce root-pavement conflicts.

**Specified Source(s) of Funding:** Virginia Tech Department of Horticulture, The Tree Fund, Virginia Urban Forest Council, Virginia Agricultural Experiment Station, Hatch Program of the National Institute of Food and Agriculture–U.S. Department of Agriculture.

9:30–9:45 AM

**Introducing Salmon Safe Eco-labeling to Green Pea/Wheat Growers in Eastern Oregon**

Clive Kaiser*
Oregon State University, Milton-Freewater, OR

Salmon-Safe was founded in 1996 and has focused on transitioning more than 300 farms and more than 60,000 acres to practices that protect water quality and native biodiversity, while building marketplace presence for ecologically sustainable farm products. Salmon-Safe has a strong presence in the Walla Walla Valley being closely aligned with Oregon LIVE and Vinea, two viticulture sustainability groups. The Valley is traversed by several salmon-bearing rivers including the Walla Walla River. Agricultural settlements are commonplace along these waterways and most of these farming entities are utilizing pesticides of one form or another. Some of these pesticides are harmful to aquatic life and end up in the streams and rivers. Minimizing the impact of these chemicals by limiting their use is paramount. Supportive efforts by the author have seen the major expansion of wine grape acreage to Salmon Safe resulting in approximately 1800 acres (70% of total acreage) being certified. In addition,
the author has also helped local Apple growers become Salmon Safe certified by establishing standards for pesticide usage in apples. Currently, there are more than 1500 acres (60% of total acreage) of Salmon Safe apples certified in the Walla Walla Valley. Recent efforts have concentrated on introducing new green pea/wheat growers to Salmon Safe. Standards have been established for these growers and initial audits have been performed. As a result, Salmon Safe have conditionally certified > 18,000 acres of green pea/wheat farmland in Umatilla County. Novel efforts to incentivize growers will be presented.

Specified Source(s) of Funding: Oregon Department of Environmental Quality

9:45–10:00 AM

The Effectiveness of Native Wetland Plants in Processing Grey Water in an Artificial Wetland System

Elizka McFedridge
University of Indiana, Bloomington, IN

John Montoya*
Texas A&M University, College Station, TX

Tina Waliczek
Texas State University, San Marcos, TX

Grey water is the term given to discharge water from bathtub/showers, sinks, and washing machines. Approximately 50% to 80% of household wastewater is grey water and 40% to 60% of water used by homeowners is directed toward the landscape; therefore, utilizing grey water in the landscape has the potential to conserve water and provide cost savings to the homeowner while providing benefits to the landscape. However, untreated grey water used on the landscape can raise soil alkalinity and have unknown environmental impact on local and groundwater sources. When filtered, homeowners could use treated grey water for landscape irrigation with a lowered potential of negative effects. Artificial wetlands have been shown to successfully remove metals, fecal coliforms, and organic and inorganic chemicals from grey water, but some typical plants used are potentially invasive in some regions of the country. The purpose of this study was to develop an artificial wetland grey water treatment system for Central Texas comprised of local and non-invasive plants to process grey water for landscape use among homeowners. Plants chosen for the experiment included local and non-invasive plants that tolerate boggy conditions. These included Typha domingensis Pers. (Cattail), Equisetum hyemale L. (Horsetail), Scirpus americanus Pers. (Bull Rush), Sagittaria platyphylla Engelm. (Arrowhead), and Eleocharis acutangula Roxb. (Texas Rush). Wetland plants were tested on their ability to remove ortho-phosphates (dissolved phosphorus) from grey water. The plants were observed and water samples were tested weekly for ortho-phosphorus, total chlorine, pH, ammonia and nitrates. The results of this pilot study indicated that Horsetail, Bull Rush and Arrowhead are the most promising plants to use in the grey water filtering system in the Central Texas region.

Oral Session—Propagation

Moderator: Kedong Da
Institute for Advanced Learning and Research, Danville, VA

9:30—9:45 AM

Ecophysiology of Seed Germination in Asarum sieboldii Miq. (Aristolochiaceae) with Underdeveloped Embryos

Seung Youn Lee
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, The Republic of

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Jeong Ho Lee*
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Asarum sieboldii is a perennial herb of the Aristolochiaceae, and has a trans-Atlantic disjunct distribution. The aims of this study were to determine the requirements for breaking dormancy and germination of A. sieboldii seeds and to compare its dormancy characteristics with those of the congener in eastern North America. Ripe seeds of A. sieboldii had an underdeveloped embryo and were permeable to water. The embryos elongated at medium temperatures in September after high temperature period in summer, and germination occurred between mid-September and early-October. After germination, seedling emergence was delayed until February, and most seedlings emerged in late March of the following year. Therefore, radicles emerge from the seeds during autumn, and cotyledons emerge the following spring. The underdeveloped embryos elongated to the critical length for germination when the seeds were moved from high (25 °C) to medium (20 °C) temperatures. Radicles did not emerge from the seeds incubated at 25 °C until the seeds were transferred to 20 °C. When the seeds were warm-stratified at 25 °C for 4, 8, and 12 weeks and then moved to spring temperatures (15 °C), more than 80% of the seeds germinated within 6 weeks, whereas less than 20% of the seeds germinated without warm stratification. Germinated seeds required subsequent chilling period for seedling emergence. When seeds with emergent radicles were cold-stratified and then moved to spring temperatures (15 °C), the cotyledons emerged. Thus, radicle dormancy is broken by high summer temperatures, and epicotyl dormancy is broken by low winter temperatures. These results suggest that the seeds of A. sieboldii have deep
Irrigation Requirements for Seed Production of Five Lomatium Species in a Semi-arid Environment

Clinton Shock*
Oregon State University, Ontario, OR
Erik B.G. Feibert
Oregon State University, Ontario, OR
Alicia Rivera
Oregon State University, Ontario, OR
Monty D. Saunders
Oregon State University, Ontario, OR
Nancy Shaw
U.S. Forest Service, Boise, ID
Francis F. Kilkenny
U.S. Forest Service, Boise, ID

Seeds of native plants are needed for rangeland restoration in the Intermountain West. Relatively little is known about the cultural practices required for seed production of these plants since they are mostly non-cultivated species. Irrigation trials were conducted for perennial Lomatium species over multiple years. Lomatium species were grown at the Oregon State University Malheur Experiment Station, Ontario, OR, received 0, 100, or 200 mm of irrigation per year. Seed yield responses were evaluated by regression over irrigation plus precipitation. In general the seed yields from the three species planted for a decade responded linearly or quadratically to irrigation. In order to improve the accuracy of irrigation water requirements, regressions were run on seed yield responses to irrigation plus precipitation during the previous spring, winter, and fall. Over multiple years Lomatium dissectum and L. triternatum seed yields were best estimated by a quadratic response to irrigation plus spring precipitation at 243 and 255 mm, respectively. Over multiple years Lomatium grayi seed yields were best estimated by irrigation plus precipitation during the fall, winter and spring at 358 mm. Two of the Lomatium species were grown for the last six years. The seed yields of Lomatium nudicaule did not respond to irrigation. Seed yields of L. suksdorfii responded linearly to irrigation in 2015.

Specified Source(s) of Funding: U.S. Forest Service Great Basin Native Plant Project

In Vitro Propagation of Ornamental Grass ‘Bowles’ Golden’ (Carex elata ‘Aurea’)

Kedong Da*
Institute for Advanced Learning and Research, Danville, VA
Samantha Smith
Institute for Advanced Learning and Research, Danville, VA
Amy Turner
Institute for Advanced Learning and Research, Danville, VA

Bowles’ Golden (Carex elata ‘Aurea’), known for its deer and moisture tolerance, is a very distinctive ornamental grass. The grasses shimmering yellow blades, with fine green edges that curl gracefully toward the ground, delicately softens any landscape. It is very well-suited for moist or wet areas, as it can thrive in up to three inches of water. It mixes beautifully with any flower bulb or perennial plants to create spectacular and elegantly mobile combinations. Traditional propagation of Bowle’s Golden sedge is accomplished through tiller separation, and elegantly mobile combinations. Traditional propagation of Bowle’s Golden sedge is accomplished through tiller separation, one plant can produce 3–5 plants in one year. Market demand of Bowle’s Golden sedge is increasing and low propagation rates are a limiting factor for this highly decorative grasses commercialization. Plant tissue culture based micro-propagation is ideal for the mass propagation of high value ornamentals, such as Bowle’s Golden. A threefold propagation rate per month was obtained by single shoot culture in MS liquid medium supplemented with BA and IAA. Shoot rooting rate was 90% in MS solid medium supplemented with 0.8 g/L activated charcoal. Plantlets were acclimatized in greenhouse with 100% survival rate.
10:30–10:45 AM

**Somatic Embryogenesis and Plant Regeneration of *Rhododendron fortunei***

Xiangying Wei*
Fujian Agriculture and Forestry University, Fuzhou, China
Dongming Pan
Fujian Agriculture and Forestry University, Fuzhou, China
Chunying Zhang
Shanghai Landscape and Gardening Research Institute, Shanghai, China
Jianjun Chen
University of Florida, Mid-Florida REC, Apopka, FL

*Rhododendron fortunei* Lindl. is a popular woody ornamental plant cultivated for its pink to pale pinkish-lilac or rose colored flowers with a sweet-scented fragrance. It has also been widely used as parents for producing hardy and fragrant hybrids. Current propagation of this species has been primarily carried out through seed, stem cutting or in vitro multiplication; however, a protocol for regeneration through somatic embryogenesis has not been established. This report describes successful plant regeneration of this species through direct somatic embryogenesis. Somatic embryos formed at and around the cut surface of leaf and petiole explants of *R. fortunei* spp. *fortunei* cultured on woody plant medium (WPM) supplemented with TDZ and NAA. Somatic embryo occurrence and embryo conversion rates were 96% and 67%, respectively for leaf explant cultured on the medium supplemented with 0.5 mg/L TDZ with 0.2 mg/L NAA, and up to 35 plantlets were produced per explant. Petiole explants cultured with 0.5 mg/L TDZ plus 0.1 or 0.2 mg/L NAA had somatic embryo occurrence rates above 95% and embryo conversion rates 80% or higher, and close to 20 plantlets were produced per explant. Plantlets produced abundant hair roots ex vitro in a soilless substrate and grew vigorously in a shaded greenhouse. This established method was not only efficient in rapid propagation of a large number of plants but also potentially be useful for improving the ornamental value of this species through genetic transformation.

An asterisk (*) following a name indicates the presenting author.
in the Midwest region of the United States, we have been studying the physiological, biochemical, and developmental fitness of the plants grown in Minnesota over the past two years. Here, we report our observations of the developmental process of saffron daughter corms without leaves and photosynthesis, which suggests a mechanism that saffron adapts to grow under drought, cold, and hot environments. We found that the daughter corms can directly initiate and grow by consuming nutrients from their mother corm. Tissues taken from different parts of the mother and daughter corms confirmed that starch granules are the principle constituent of the corms. A prominent vascular tissue structure was observed in the junction between mother and daughter corms, staining of the tissue with different dyes showed conversion of starch granules to sucrose in the cells of mother corms and sucrose to starch granules in the cells of daughter corms. Further molecular and biochemical investigation for this process is needed in order to advance our understanding of the feasibility of growing saffron in the Midwest as a specialty crop.

10:15–10:30 AM

Resurrecting the Medicinal Uses of *Brassica oleracea* Seed: Combining Genotypic Information with Growth Protocols to Promote Anti-inflammatory Chemicals

Katherine Warpeha*
University of Illinois at Chicago, Chicago, IL
Carlos Montero
University of Illinois at Chicago, Chicago, IL
Nayfah Thnaibat
University of Illinois at Chicago, Chicago
Shamaila Zaheer
University of Illinois at Chicago, Chicago, IL
Benjamin Okkema
University of Illinois at Chicago, Chicago, IL

In order to develop easy to find, and easy to grow, affordable medicinal plants we investigated the potential chemical constituencies and anti-inflammatory chemical production of public varieties of Broccoli (*Brassica oleracea* Italica) made stress resistant. While many varieties of broccoli have anti-inflammatory chemicals in the seeds, we sought to greatly enhance phenylpropanoids and glucoraphanin in 300,000 seeds by EMS mutagenesis and a stress-inducing growth protocol, post-EMS treatment. EMS mutagenesis occurred in the dark. After treatment, seeds were germinated and then on day 5, we scored ~58,000 survivors. The survivors were treated with stressful levels of abiotic signals, then were subjected to a simple but specific growth protocol. The resultant population of survivors was scored three weeks later, and was only 0.05% of the beginning population, where most of the survivors were hardy and had presented altered pigmentation. Leaf punch disks of survivors revealed by chemical and absorbance analysis that these methods produced more chemicals per mass of the desired chemical groups. Three types of survivor phenotypes are observed and are being further characterized. Plants are being selfed in the expectation that these lines can be further studied and undergo analytical chemistry to identify exact constituents in the sprouts, for an affordable and compact way to obtain potent medicinal chemicals that have been implicated as being anti-cancer and anti-inflammatory. These lines are compared to untreated heirloom broccoli varieties for chemical constituents.

Specified Source(s) of Funding: University of Illinois at Chicago

10:30–10:45 AM

Four Growing Seasons in High Tunnels

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University of Wyoming, Laramie, WY
Timm M. Gergeni
University of Wyoming, Laramie, WY
Casey Seals
University of Wyoming, Laramie, WY
Andrea R. Garfinkel
Washington State University Pullman, WA

Over the course of four years we studied crop growth and yields in two high tunnels. The tunnels are oriented perpendicular to each other, one on an east–west axis, the other north–south. Each tunnel is 3.7 x 4.9 m, with a central aisle and roll-up sides for ventilation. We grew fresh cut sunflowers in 2012; basil, chives, marjoram, and oregano in 2013 and 2014; and chives in 2015. Fresh cut sunflowers showed longer stem lengths when grown in the north-south tunnel (103 to 157 cm, depending on cultivar) than those grown in the east-west tunnel (104 to 118 cm, depending on cultivar). There were no differences, however, in days to harvest between the two tunnels, ranging from 77 to 95 days, depending on cultivar. Fresh market herbs showed differences depending on species and year. Basil total fresh weight was highest in the east–west tunnel in 2013 (mean 196 g per plant) but highest in the north–south tunnel in 2014 (mean 285 g per plant). Oregano fresh weight was highest in the north-south tunnel both years (mean per plant 234 g in 2013 and 213 g in 2014). Like basil, marjoram fresh weight was highest in the east–west tunnel in 2013 (mean 229 g per plant) but higher in the north–south tunnel in 2014 (mean 289 g per plant). Chives fresh weight was highest in the east–west tunnel both years (mean 31 g in 2013 and 80 g in 2014). Chives fresh weight was highest in the east–west tunnel both years (mean 49 g per plant) as opposed to the east–west tunnel (mean 44 g per plant). There were also differences among the four locations within the tunnels over the four years: east and west sides of the central aisle in the north–south tunnel and north and south sides of the aisle in the east–west tunnel. These differences indicated the east exposure in the north–south-oriented tunnel was generally most favorable for production of the crops grown.

Specified Source(s) of Funding: University of Wyoming Agricultural Experiment Station, Wyoming Department of Agriculture Specialty Crops Grant
An asterisk (*) following a name indicates the presenting author.

**Oral Presentations**

10:45–11:00 AM

**Irrigation Criteria Affects Both Stevia rebaudiana Leaf Yield and Leaf Steviol Glycoside Composition**

Cheryl A. Parris*
S and W Seeds, Fresno, CA

Clinton Shock
Oregon State University, Ontario, OR

Stevia (Stevia rebaudiana) is a perennial herbaceous plant native to Paraguay and used traditionally by the native Guarani peoples for centuries to sweeten medicinal teas. Stevia has only been commercially cultivated over the past 50 years and cultural practice information suitable for implementation by growers is limited. Currently stevia’s commercial value is found in its steviol glycoside content, especially rebaudioside A. The current trial investigated the effect that soil water tension as irrigation onset criteria had on stevia dry leaf yields, steviol glycoside content and yield, and steviol glycoside ratios. The experiment was conducted at the Oregon State University, Malheur Experiment Station, Ontario, OR. Two stevia varieties, SW109 and SW129 (S&W Seed Company Inc., Fresno, CA), were subjected to soil water tension irrigation criteria of 10, 20, 40, 60, 80, kPa over a 57-day trial period. Harvested plant material was measured for dry leaf yield and several steviol glycosides. Evaluating variety response to irrigation by regression analysis, results showed a highly significant decrease in stevioside % content, and an increase in the ratio of rebaudioside A to stevioside from drier to wetter irrigation onset criteria. The rebaudioside A % content did not show any significant trend at differing irrigation criteria. The results indicate that maximizing dry leaf productivity directly affects rebaudioside A yield, which in turn can provide increased crop value to the grower. Irrigating near 10kPa produced higher dry leaf yield and rebaudioside A yield, than irrigation at drier criteria. Irrigating stevia at 10 kPa at full canopy, the crop coefficient, k_c, was equivalent to 0.97 Eto.

11:00–11:15 AM

**Effects of Different Temperatures on Some Biochemical Contents in Garlic Bulbs**

Meryem Ipek*
Uludag University, Bursa, Turkey

Asuman Cansev
Uludag University, Bursa, Turkey

Ahmet Ipek
Uludag University, Bursa, Turkey

Saime Koccat
Uludag University, Bursa, Turkey

Mehmet Cansev
Uludag University, Bursa, Turkey

Garlic (Allium sativum L.) bulbs are generally kept at ambient temperature after harvest until their consumption. Storage at ambient temperature could decrease the nutritional benefits of garlic bulbs. Therefore, cold storage after harvest is recommended to maintain garlic bulbs at the most beneficial stage. In this study, bulbs of PI515971 and Kastamonu garlic genotypes were stored at 4 °C and 21 °C for 12 weeks and changes in total soluble protein, total thiosulfimates, sucrose, fructose, and glucose contents were measured at pre-storage and four weeks intervals during storage. In general, total soluble protein content extracted from leaf primordia of cloves increased at 4 °C storage but remained unchanged at 21 °C storage in both genotypes. Total thiosulfimates increased at both temperatures but it was higher at 4 °C storage. Sucrose and fructose contents of the bulbs of PI515971 genotype increased during eight weeks of storage but the increase was higher at 4 °C. On the other hand, the response of Kastamonu garlic was different for sucrose and fructose contents. While there was a decrease in sucrose content after four weeks of storage at both storage temperatures, the fructose content increased significantly at 4 °C storage. Glucose contents of both genotypes increased at 4 °C storage but did not change at 21 °C storage. These results demonstrated that cold storage of garlic bulbs had generally more positive effect on content of biochemical measured in this study.

**Specialized Source(s) of Funding**: The Scientific and Technological Research Council of Turkey (TUBITAK-TOVAG)

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**Oral Session—Floriculture 1**

**Moderator**: William Wheeler
University of Georgia, Athens, GA

10:15–10:30 AM

**Ethephon Applied during the Bulking Phase of Clematis Production Increases Shoot Number Following Vernalization**

Uttara Samarakoon*
The Ohio State University, Wooster, OH

James Faust
Clemson University, Clemson, SC

Alexandra Carver
Clemson University, Clemson, SC

Jordan Baylor
Clemson University, Clemson

Clematis production has not traditionally fit into the standard floriculture greenhouse production systems because of the relatively long (2-year) production cycle from propagation to flowering. Our previous research focused on understanding the influence of the duration of the cold treatment and photoperiod on shoot growth and flowering of Clematis × hybrida ‘H.F. Young’. Specifically, a cold treatment at 5 °C for 9 weeks followed by a 16-h photoperiod promoted flowering. Current experiments focused on shortening the production time to 1 year. Since flower induction was well understood, the limitation to a 1-year cycle was the lack of branching observed on 1-year-old plants. Our hypothesis was that a well-branched, flowering plant could be
examined the effect of ethephon (0, 500, or 1000 mg·L⁻¹) applied as a foliar spray to plants 4, 6, 21 and 23 weeks after transplanting. Plants were then exposed to a 9-week cold treatment (5 °C) and forced in a heated greenhouse under a 16-h photoperiod. Prior to the cold treatment there were no differences in shoot numbers (2 shoots per plant) between treatments; however, following the cold treatment, plants treated with ethephon (500 mg·L⁻¹) had three more shoots/plant than the other treatments. A second experiment examined the effect of ethephon (0, 500, or 1000 mg·L⁻¹) applied eight times during the bulking period and grown at either a 9-h or 16-h photoperiod during the last 10 weeks of bulking prior to receiving a cold treatment. All ethephon-treated plants developed three more shoots during the bulking phase as compared to the control. However, following cold treatment the 1000 mg·L⁻¹ ethephon treatments produced plants that experienced delayed flowering, shorter stem length, and excessively high shoot number. Therefore, we recommend using 4–6 applications of 500 mg·L⁻¹ ethephon during a 24-week vegetative bulking period to produce a commercially acceptable clematis crop in 1 year from the start of propagation to the time of first open flower.

10:30–10:45 AM

**Growth and Development of Petunia (Petunia x hybrida) Cultivars Grown Under Reduced Air Temperature Production in Combination with Bench-top Root-zone Heating**

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

Madeline W. Olberg
Purdue University, West Lafayette, IN

Heating accounts for up to 30% of the total operating costs for greenhouse operations in northern latitudes. Growers often lower greenhouse air temperatures to reduce energy costs; however, development is delayed even in cold-tolerant crops such as petunia (Petunia x hybrida). This delay increases production time and reduces profitability. Recent studies indicate that petunia is a strong candidate for production using reduced MDT in combination with bench-top root-zone heating (RZH) to prevent or reduce delays in development. The objectives of this study were to: 1) quantify time to flower (TTF) of nine petunia cultivars when the MDT was reduced by 5 °C and bench-top RZH was utilized 2) determine if high-quality petunias can be produced on RZH. Petunia ‘SunSpun Burgundy’, ‘SunSpun Lavendar Star’, ‘Sanguna Patio Red’, ‘Potunia Plus Red’, ‘Potunia Plus Purple’, ‘Supertunia Red’, ‘Supertunia Bordeaux’, and two recombinant inbred lines were grown in a greenhouse with a constant air temperature of 15 °C without RZH or with a RZH set point of 21, 24, or 27 °C. Additionally, plants were grown in a separate greenhouse without RZH and a constant air temperature of 20 °C. All plants were grown under a 16-h photoperiod with daylight extension lighting delivered from high-pressure sodium (HPS) lamps to provide a DLI of 10 to 12 mol·m⁻²·d⁻¹. As RZH temperature increased, TTF significantly decreased for all cultivars. For example, TTF of ‘Potunia Plus Red’ was 56, 52, 49, or 47 d for plants grown at a MDT of 15 °C without RZH, or with RZH set points of 21 °C, 24 °C, or 27 °C, respectively. When a RZH set point of 27 °C was employed, TTF of all cultivars, except ‘Potunia Plus Red’ and ‘Sanguna Patio Red’, was similar to plants grown at a MDT of 20 °C and no RZH. Reduced stem elongation, growth index, and shoot dry mass were observed when plants were grown with RZH. For example, stem elongation was reduced by 1.6, 1.7, and 3.8 cm for ‘Potunia Plus Red’, ‘Sun Spun Lavender Star’, and ‘Supertunia Bordeaux’ grown at a MDT of 15 °C with a RZH set point of 27 °C in comparison to without RZH. Producing a compact plant in a shorter time period is beneficial for greenhouse growers; thus, results suggest that MDT can be reduced to 15 °C for petunia production when a RZH set point of 27 °C is employed.

10:45–11:00 AM

**Sensor-based Automated Irrigation Impacts Pythium aphanidermatum Infection in Petunia x hybrida ‘Dreams Red’**

William Wheeler*
University of Georgia, Athens, GA

Jean Williams-Woodward
University of Georgia, Athens, GA

Matthew Chappell
University of Georgia, Athens, GA

Paul Thomas
University of Georgia, Athens, GA

Marc van Iersel
University of Georgia, Athens, GA

The use of soil moisture sensors to monitor root zone volumetric water content (θ) and automate irrigation in container grown ornamental crops has been accomplished in both research and commercial settings. The ability of real-time monitoring and control afforded by these systems allows for precise θ to be maintained, thereby reducing variability in root zone moisture contents. Cyclical soil moisture profiles created by traditional irrigation management subject crops to soil moisture extremes that increase incidence and severity of root infection. Observations in commercial trials have suggested a reduction in losses due to root disease when comparing sensor-based automation to that of grower managed irrigation. Based on these observations, trials were conducted in a controlled setting in July and September of 2015 at the University of Georgia horticulture greenhouse complex in Athens, GA. Petunia x hybrida ‘Dreams Red’ were grown using a soil moisture sensor based automated irrigation system that maintained substrate θ at 0.2, 0.3, and 0.4 m³·m⁻³, as well as creating a cyclic soil moisture profile which underwent a 25% change in θ (0.18 to 0.43 m³·m⁻³).
between irrigation events. Once established half of the plants were inoculated with *Pythium aphanidermatum* and grown out for one month. Probability of root infection was lowered when θ was maintained at 0.2 m·m⁻¹ compared to those maintained at 0.4 m·m⁻¹ and cyclical θ. Mortality, biomass, and aesthetic quality were all unaffected by irrigation regime in both control and inoculated treatments.

11:00–11:15 AM

**Productivity and Timing of Harvest Maturity of Gentian ‘Showtime Diva’; Influence of Dormancy-breaking Treatments, Development Stage, and Crown Bud Ontogeny**

Uttara Samarakoon*
The Ohio State University, Wooster, OH

David Woolley
Massey University, Palmerston North, New Zealand

Ed Morgan
The New Zealand Institute for Plant & Food Research Limited, Palmerston North, New Zealand

Keith Funnell
The New Zealand Institute for Plant & Food Research Limited, Palmerston North, New Zealand

In the recent years new gentian cultivars have been released for production of cut flowers or potted plants. Cut flower productivity and spread in duration of harvest maturity of these cultivars has been identified as a concern by commercial growers. Flowering shoots of gentian develop from overwintering crown buds produced with a requirement of chilling for shoot emergence. Inadequate accumulation of chill units, was hypothesized as a possible reason for variation in timing in shoot emergence and flowering. Since crown buds originate from bud clusters, the hierarchical arrangement of buds within clusters was also hypothesized to contribute to this variation. Experiments were carried out with the gentian cultivar ‘Showtime Diva’, to determine the response to treatments that break dormancy (chilling (5 °C), gibberellic acid (GA₃)) applied at different stages of development of crown buds. The application of GA₃ (100 mg·L⁻¹) increased emergence of crown buds as shoots, leading to development of more flowering shoots. A similar response was observed with exposure to chilling, but only on plants with non-emerged crown buds or with shoot emergence commencing. Both chilling and GA₃ could reduce the time to, and spread of, harvest maturity, if applied prior to shoot emergence. The hierarchical relationship of buds in crown bud clusters led to differential responses to application of GA₃. Buds positioned at the proximal end of the bud cluster took a similar duration to reach shoot emergence or harvest maturity. For buds located at the distal end the duration to reach shoot maturity took an extra 14 days to reach harvest maturity with each increment in hierarchical position. The response to chilling and/or GA₃ therefore varied based on, the development stage of the plant at the time of application and, the hierarchical position of the crown buds within the cluster. The current study enabled identification of factors associated with the variation in number of floral shoots and spread in time to harvest maturity in gentian.

**Oral Session—Improvements in Weed Control and Soil Nutrition Enhance Citrus Natural Resistance to HLB Disease**

Moderator: Craig Ramsey
USDA-APHIS, Fort Collins, CO

10:15–10:30 AM

**Evaluation of Ozonated Water for Sanitizing Recycled Greenhouse Irrigation Water**

Craig Ramsey*
USDA-APHIS, Fort Collins, CO

Debra Newman
USDA-APHIS, Fort Collins, CO

Paul Freebury
USDA-APHIS, Fort Collins, CO

Steven Newman
Colorado State University, Fort Collins, CO

A cooperative agreement between Colorado State University and USDA-APHIS-PPQ-CPHST lab was funded in 2014 to test the ability of ozonated water to sanitize recycled irrigation water in greenhouses. A custom built ozone generator supplied the ozonated water for the study. A private microbiology lab prepared and analyzed the *Bacillus subtilis* spore samples used as the hard-to-kill surrogate for bio-contaminated water. The study involved three factors: 1) two *B. subtilis* spore types (normal and super dormant spore samples), five ozonated water concentrations (0, 10, 15, 20, and 25 ppm), and three exposure times (5, 10, and 15 minutes). Ozonated water was generated then added to the spore suspensions for each of the 30 treatments. The Oxidation Reduction Potential (ORP) ranged from 511 to 980 mv for the four ozonated water concentrations. The percent spore inactivation ranged from 87% to 99.9%, across the 30 treatment combinations. Increasing the ozonated water ORP and/or the exposure time increased spore efficacy. Further increases in spore efficacy may be achieved by extending the exposure time, or using repeated ozonated water applications.

**A Multiple Component Approach to Manage Citrus Diseases for Optimum Productivity**

Donald J. Huber*
Purdue University, Melba, ID (retired)

Craig Ramsey
USDA-APHIS, Fort Collins, CO

Recognition of how nutrition interacts to suppress disease
Huanglongbing is a bacterial disease in citrus 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, poor host nutrient acquisition and use, disruptive host metabolism, and, host immune system capabilities. 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 and inhibited metabolites. These weed control and fertilizer changes reduced or eliminated symptoms of citrus greening.

**Oral Session—Viticulture and Small Fruits 2**

Moderator: Renee Threlfall
University of Arkansas, Fayetteville, AR

10:15–10:30 AM

**Phylloxera (Daktulosphaira vitifolia) Utilizes Floral/Fruit Organ Developmental Genes As a Mechanism for Gall Formation on Vitis Leaves**

Trudi Grant*
University of Florida, Mid-Florida REC, Apopka, FL

Zhijian Li
University of Florida, Mid-Florida REC, Apopka, FL

Heidi Appel
University of Missouri, Columbia, MO

Jack Schultz
University of Missouri, Columbia, MO

Dennis Gray
University of Florida, Mid-Florida REC, Apopka, FL

Molecular insights into the mechanisms underlying the complex relationship between grape phylloxera (Daktulosphaira vitifolia Fitch) and its host shows that the highly specialized galls induced on grape leaves may be as a result of the ectopic activation or redirection of flower and/or fruit development pathways via phytohormones. RNA sequencing and RT-PCR data collected from galled and un-galled tissues revealed changes in the expression of several key genes involved in floral/fruit development and hormone signaling, with LEAFY, the Vitis homologs that regulate the transition to flowering, WUSCHEL, which maintains the pluripotent stem cell pool in the shoot apical meristem and AGAMOUS, a carpel-identity gene, being some of the genes to increase in expression as galls develop and mature. Transgenic plants with targeted silencing of these genes were created to determine the correlation between changes in their expression and successful galling. Evaluation of transgenic selections of ‘Seyval Blanc’ (Vitis spp.), a susceptible hybrid cultivar, by direct challenge with D. vitifolia revealed plants showing increased resistance to phylloxera, and some exhibiting limited-to-no gall formation at all. This is an important step in understanding the insect’s ability to manipulate plant morphogenesis in order to create such specialized structures. Controlling gene(s) identified via this knock-out approach can be modified to create phylloxera resistant cultivars.

**Specified Source(s) of Funding:** National Science Foundation
Impact of Cluster Thinning on ‘Pinot Noir’ Fruit Quality Across a Large-scale, Multi-site Study
Patricia Skinkis*
Oregon State University, Corvallis, OR

Premium wine grape production regions have long-held traditions of maintaining low yields to achieve high fruit and wine quality. A large scale, multi-site study was designed to determine the impact of reducing yield on vine performance and fruit composition of Vitis vinifera ‘Pinot noir’ winegrapes in Oregon. The trial was conducted annually in more than 10 commercial vineyards from 2012 to 2014. Each site had two or more yield levels implemented at lag phase of berry development using cluster thinning down to a pre-determined number of clusters per shoot. The majority of vineyards implemented one cluster per shoot, two clusters per shoot and/or full crop (non-thinned). All thinning treatments were applied to whole rows in a randomized complete block design with three replicates across blocks that ranged 0.4 to 1.2 hectares. Given the differences in baseline yield over the three years, cluster thinning resulted in an average yield reduction of 0.53, 0.45, and 0.77 kg·m\(^{-1}\) in 2012, 2013, and 2014, respectively. Fruit composition at harvest, including basic ripening parameters, yeast assimilable nitrogen, anthocyanin and phenolics, did not differ by cluster thinning within 30% of sites each year. For the remaining 70% of sites, there were few consistent differences in these parameters over the three years. However, the most consistent effect was found for anthocyanin concentration. A negative linear regression for yield and polymeric anthocyanin was found in 20%, 29%, and 42% of vineyards in the study during 2012, 2013, and 2014, respectively. Significant regressions were found for total anthocyanin at only 10% of sites in 2012, the lowest yield year, and 30% of sites in both 2013 and 2014. The mean difference in anthocyanin concentration across years and sites was 2 mg·L\(^{-1}\) higher polymeric anthocyanin and 162 mg·L\(^{-1}\) higher total anthocyanin in fruit-thinned vines compared to those with full crop. There were no differences in dormant pruning weight for any site, even after three years of vines carrying a full crop level, suggesting that vines were not overcropped. These data suggest that ‘Pinot noir’ vines had sufficient vine size to support fruit ripening; however, cluster thinning increased anthocyanin in some sites which may increase wine color intensity, an important quality parameter for red wines.

Specified Source(s) of Funding: Oregon Wine Research Institute, Oregon Wine Board

Influence of Woody Lateral Shoot Presence on ‘Pinot noir’ Bud Fruitfulness
Alison L. Reeve*
Oregon State University, Corvallis
Patricia Skinkis
Oregon State University, Corvallis, OR

Grapevine bud fruitfulness, the number of inflorescence primordia within the dormant compound bud, has been linked to carbon assimilation and/or carbohydrate reserves in several studies. Summer lateral shoots, which arise from the same leaf axil as the compound bud, require assimilates early in their formation, potentially competing with inflorescence primordia in the newly developing bud. Lateral can become lignified by dormancy, and the presence of a woody lateral at a given node was investigated for its impact on bud fruitfulness (FFL) and on the Integrated Fruitfulness Index (IFI) which is the sum of inflorescence primordia diameters in the bud. A total of 240 one-year canes were collected from fruiting arms (2-year old canes) and 120 canes from renewal spurs of ‘Pinot noir’ at dormancy in early 2015. Canes were weighed and dormant compound buds from nodes five to 15 (as laterals are uncommon at nodes one to four) were evaluated for FFL and IFI within each of the three buds within the compound bud, and the presence of a woody lateral was noted for each. Node position, cane weight, and lateral presence influenced both FFL and IFI determined by multiple regression, with significant interactions for cane weight x lateral presence and node position x lateral presence. Data were then paired by presence or absence of lateral for each node and field plot and paired t-tests were run. Given the same node position, buds at nodes with a lateral present had 25% to 83% higher FFL and 29% to 100% higher IFI than those without laterals. The increase in FFL and IFI was due to higher primary bud FFL and IFI at all nodes except node five and higher FFL and IFI in secondary buds at all nodes except nodes seven and ten. At a given node position, a heavier cane had a higher FFL and IFI than the same node on a lighter cane, given the presence (or absence) of a woody lateral at both nodes. These findings suggest that nodes with woody laterals at dormancy do not limit inflorescence primordia initiation or growth compared to nodes without a lateral at dormancy, possibly through increased photoassimilation of the subtending lateral. To the authors’ knowledge, this is the first association in wine grapes for increased fruitfulness at nodes with woody laterals present.

Specified Source(s) of Funding: Oregon Wine Board, Agricultural Research Foundation

Defining and Automating Optimal Dormant Pruning
Peter Hirst*
Purdue University, West Lafayette, IN
Tara Baugher
Pennsylvania State University Coop. Ext., Gettysburg, PA
Noha Elfiky
Purdue University, West Lafayette, IN
Leland Glenna
Pennsylvania State University, University Park, PA

An asterisk (*) following a name indicates the presenting author.
Pruning is an essential horticultural practice but is very labor intensive. Previous attempts at mechanical pruning have mostly involved non-discriminating hedging that leads to poor light distribution within the tree canopy and reduced fruit quality.

In this study we developed and evaluated pruning heuristics for grapes and apples. These pruning “rules” led to horticultural outcomes, such as yield and fruit quality, broadly similar to those resulting from pruning by commercial human pruning crews. Vine and tree canopies were captured using cameras and sensors, then reconstructed accurately in 3D. Pruning heuristics were then applied to the reconstructions to determine optimal pruning points. This work has applications for the development of autonomous pruning, with a robotic grapevine pruner currently being tested and evaluated. Another potential application of this work is in the development of more effective training methods for human pruning crews. Grower attitudes toward the science of pruning appeared to depend on the size of their orchards.

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

**11:30–11:45 AM**

**Sensory and Composition Attributes of Arkansas Blackberry Cultivars**

Natchez Tree Nursery, Pottsville, AR

**11:15–11:30 AM**

**Oral Presentations**

**Viticultural Traits of Three Pierce’s Disease-resistant *Vitis vinifera* L. Selections in Alabama**

Andrey Svyantek*

Auburn University, Auburn, AL

Elina Coneva

Auburn University, Auburn, AL

J. Raymond Kessler

Auburn University, Auburn, AL

James Schupp

Pennsylvania State University, Biglerville, PA

Bret Wallach

Vision Robotics Corp., San Diego, CA

Pennsylvania State University, University Park, PA

Auburn University, Auburn, AL

Auburn University, Auburn, AL

To understand the attributes of *V. vinifera* grown in central Alabama’s humid subtropical climate, averaging over 130 cm in annual precipitation, vine vigor was notable in all three selections as characterized by dormant pruning weights and trunk cross sectional area (TCSA). In 2016, TCSA was greatest for ‘502-01’ (188.7 cm²). In both 2015 and 2016 ‘501-12’ had the smallest TCSA. Ravaz index based on the 2015 crop and 2016 pruning weights indicated differences between selections: ‘501-12’ had the smallest Ravaz index at 3.1 while selections ‘502-01’ and ‘502-10’ both had a Ravaz index of 4.5. All tested selections were slightly below the recommended Ravaz index ranges for *V. vinifera* cultivars. Dormant pruning weights revealed high vigor for all selections. ‘501-12’ had the highest pruning weight of 2.9 kg/vine, followed by ‘502-01’ and ‘502-10’ with similar pruning weights of 2.4 kg/vine and 2.5 kg/vine, respectively. As *V. vinifera* selections become a commercially available planting option for southeastern vineyards, it will be increasingly important to further refine concepts of vine balance and vigor to enable development of economically and environmentally sustainable management techniques in the southeastern region.

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

**11:15–11:30 AM**

**Viticulture of Three Pierce’s Disease-Resistant *Vitis vinifera* L. Selections in Alabama**

Andrey Svyantek*

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

**11:30–11:45 AM**

**Sensory and Composition Attributes of Arkansas Blackberry Cultivars**

Renee Threlfall*

University of Arkansas, Fayetteville, AR

Daniela M. Segantini

University of Arkansas, Fayetteville, AR

John Clark

University of Arkansas, Fayetteville, AR

**Blackberry Cultivars**

Fresh blackberries (*Rubus* subgenus *Rubus*) are consumed worldwide for commercial markets, but there is limited information on commercial sensory attributes. Fresh blackberry cultivars (Natchez, Osage, Ouachita, Prime-Ark® 45, and Prime-Ark® Traveler) were harvested in 2014 at the shiny black stage of maturity from the University of Arkansas Fruit Research Station, Clarksville. The initial composition of the blackberries were measured, and average berry weights ranged from 7.3 (‘Osage’) to 14.3 g (‘Natchez’), soluble solids from 8.9 (‘Osage’) to 10.6% (‘Ouachita’), and titratable acidity of 0.7 (‘Ouachita’) to 1.0% (‘Natchez’). A trained descriptive panel (n = 9) and a consumer panel (n = 74) evaluated sensory attributes of these cultivars. The descriptive panel evaluated fresh blackberry attributes including appearance (size of berry and glossiness), basic tastes (sweet, sour, and bitter), overall aromatics, and firmness using a 15-point scale (0 = less and 15 = more of the attribute). The consumer panel evaluated appearance, size, shape, color, overall impression, overall flavor, and firmness of fresh blackberries on a 9-point verbal hedonic scale (1 = “extremely dislike”; 9 = “like extremely”). The descriptive panel identified ‘Natchez’ as the largest, glossiest, sweetest, and most aromatic cultivar. ‘Osage’ was the smallest and least aromatic, ‘Prime-Ark® 45’...
was the least glossy, sweet, and firm, and ‘Prime-Ark® Traveler’ was the least bitter. Descriptive panelists found no differences in sourness. ‘Osage’ and ‘Osage’ were the firmest and most bitter. Consumer panelists “liked” all attributes (6.4–7.9 on a 9-point scale) measured among the cultivars evaluated. There was no difference in the “liking” for shape, color, or firmness of the cultivars. ‘Prime-Ark® Traveler’ had the highest liking scores for appearance, size, overall impression, and overall flavor. For appearance and size, the least-liked cultivars were ‘Osage’ and ‘Natchez’, respectively. ‘Natchez’, a 14.3 g berry with soluble solids of 10.0% and titratable acidity of 1.0%, had some of the highest descriptive attributes, but ‘Prime-Ark® Traveler’, a 9.0 g berry with a 9.0% soluble solids and 0.9% titratable acidity was the most liked by the consumers. Identifying the key sensory attributes for blackberries can be used to determine commercial potential.

Specify Source(s) of Funding: Specialty Crop Block Grant from the Arkansas Agriculture Department, U.S. Department of Agriculture (14-SCBGP-AR0005)

11:45–12:00 PM

Changes in Composition and Descriptive Sensory Attributes of Blackberries during Postharvest Storage

Daniela M. Segantini*
University of Arkansas, Fayetteville, AR

Renee Threlfall
University of Arkansas, Fayetteville, AR

John Clark
University of Arkansas, Fayetteville, AR

Five blackberry cultivars (Natchez, Osage, Ouachita, Prime-Ark® 45 and Prime-Ark® Traveler) from the University of Arkansas blackberry breeding program were evaluated to measure changes in composition and sensory attributes during postharvest storage. Berries were harvested in June 2015 at the shiny-black stage of maturity and placed in 240-g vented clamshells in triplicate. Data were collected on berries both before and after storage at 2 °C (90% RH) for 7 d. A trained descriptive sensory panel (n = 9) evaluated sensory attributes of the blackberry cultivars, each panelist evaluated four berries for each cultivar in duplicate, served monadically and randomized. The descriptive panelists identified and evaluated the basic tastes (sweet and sour) and texture (firmness) of fresh blackberries using a 15-point scale (0 = less of the attribute and 15 = more of the attribute). Analytically, firmness, soluble solids content (SSC) and titratable acidity (TA) were also evaluated. At day 0, the cultivars had firmness from 4.9 to 7.2 N, SSC from 7.9% to 9.2% and TA from 0.7% to 1.2%. At day 0 panelists scaled hardness of blackberry from 3.5 to 3.9, sourness from 3.6 to 5.5 and sweetness from 4.0 to 4.9. Storage did not affect firmness as cultivars averaged 5.7 N at day 0 and 5.4 N at day 7, nor could panelists differentiate firmness differences (day 0 = 3.75 or day 7 = 3.77). The level of SSC did not differ among genotypes and was not affected by storage, however panelists detected differences in sweetness between stored berries and among genotypes. Results for TA before and after storage indicated that TA was reduced in storage, an average across genotypes of 1.0% before storage to 0.8% after storage. However, ‘Osage’ showed an increase of TA (day 0 = 0.7% and day 7 = 1.1%), while ‘Osachita’ showed a decrease of TA (day 0 = 1.2% and day 7 = 0.7%). Panelists did not detect changes in sourness for ‘Osachita’, but perceived an increase of sourness for ‘Osage’ (day 0 = 3.6 and day 7 = 4.5) and a decrease of sourness for ‘Natchez’, ‘Prime-Ark® 45’ and ‘Prime-Ark® Traveler’. The cultivars analyzed showed great fresh-market potential due to their maintenance of firmness, along with SSC and TA after storage.

Specify Source(s) of Funding: Specialty Crop Block Grant from the Arkansas Agriculture Department, U.S. Department of Agriculture (14-SCBGP-AR0005)

12:00–12:15 PM

Field Evaluation of Raspberry Cultivars in North Dakota

Wenhao Dai*
North Dakota State University, Fargo, ND

Victoria A. Magnusson
North Dakota State University, Fargo, ND

Ryan R. Lenz
North Dakota State University, Fargo, ND

Raspberry has been widely used for fresh consumption and processed products in the world. Recently there has been increasing interest in raspberry production in the northern Great Plains due to its high soluble fiber, vitamins, and minerals. In North Dakota, harsh winter conditions often result in considerable winter injury of many floricane raspberries and a short growing season will result in a lower yield because a large percentage of fruits remain immature before the fall frost. In this study, ten floricane cultivars (‘Prelude’, ‘Boyne’, ‘Killarney’, ‘Nova’, ‘Meeker’, ‘Latham’, ‘Encore’, ‘Amthyst’, ‘Royalty’, and ‘Mac Black’) and nine primocane cultivars (‘Polana’, ‘Autumn Bliss’, ‘Autumn Britten’, ‘BP-1’, ‘Himbo-Top’, ‘Joan J’, ‘Caroline’, ‘Heritage’, and ‘Anne’) that were reported to have good hardiness and fruit quality are being field evaluated in North Dakota. The experiment is a randomized complete-block design (RCBD). Each block contains 4–6 plants per cultivar and replicated 4–6 times (blocks). The planting spacing is 9’ x 5’ and the “V”-shape trellis system was used. One year result (2014) indicated that seven floricane cultivars survived the winters with various degrees of winter injury. ‘Prelude’, ‘Boyne’, ‘Killarney’, ‘Amthyst’, ‘Latham’, and ‘Nova’ showed no or very minor winter damage. ‘Encore’ showed some dieback. Primocanes of ‘Polana’ were vigorous and produced fruits in early August to early October. ‘Prelude’ is the earliest ripening cultivar with 5% of fruits being harvested on 7 July, followed by ‘Killarney’, ‘Boyne’, ‘Nova’, and ‘Encore’. Polana had the longest harvest duration (62 d). ‘Polana’, ‘Killarney’, and ‘Nova’ produced the largest fruit size. Various soluble sugar contents (SSC), firmness, and flavor were observed in cultivars. Winter
hardiness, fruit quality, and resistance to major pests will be evaluated in the following years.

Oral Session—Temperate Tree Nut Crops

Moderator: Megan Muehlbauer  
Rutgers University, New Brunswick, NJ

11:30–11:45 AM

Mechanical Pruning Improves Pecan Kernel Antioxidant Capacity over Three Consecutive Harvest Years

Yi Gong  
University of Georgia, Athens, GA

Richard Heerema*  
New Mexico State University, Las Cruces, NM

Joshua Sherman  
University of Arizona, Willcox, AZ

Marisa T. Potter  
New Mexico State University, Las Cruces, NM

Brad Lewis  
New Mexico State University, Las Cruces, NM

Ronald B. Pegg  
University of Georgia, Athens, GA

Pecan (Carya illinoinensis) is the most horticulturally important tree nut native to North America. Pecan kernels are an excellent source of important nutrients and bioactive compounds, notably phenolics. There is a growing demand for pecans in domestic, Indian, and Asian markets. Alternate bearing is a serious horticultural problem in pecan orchards. In the southwestern United States, alternate bearing is primarily managed through mechanical pruning programs. The objective of our study was to investigate the effects of mechanical pruning on kernel antioxidant capacity. Our study was conducted in a bearing ‘Western’ pecan orchard in the Mesilla Valley, NM. Beginning in 2006, trees were subjected to a range of mechanical pruning frequency treatments (unpruned, annual, biannual, and triannual pruning) paralleling conventional practices. At kernel maturity, nuts were sampled from three canopy-height zones in each of the 2012–14 seasons. Phenolic compounds were extracted from defatted nutmeat using an acidified acetone extractant. The Total Phenolics Content (TPC) and Oxygen Radical Absorbance Capacity (H-ORAC<sub>FL</sub>) assays were conducted to assess the in vitro phenolics contents and antioxidant capacities of the nutmeats, respectively. Glycoside-linked and ester-linked phenolics were further liberated from crude phenolic preparations by acid and base hydrolysis, respectively. These fractions were analyzed by HPLC with a fused-core C18 column. Results showed that alternate bearing significantly impacts (P < 0.05) antioxidant capacities when all samples were grouped by harvest year. Higher TPC and H-ORAC<sub>FL</sub> values were associated with pecans sampled during “on” year than “off” year. But when compared with non-pruned, the severity of alternate bearing was alleviated in all samples with pruning treatments applied across the three-year span, regardless of pruning frequency. Close examination of HPLC results for all 3 fractions revealed a standard set of phenolic compound profile in all samples, while a significant escalation for the concentration of elagic acid and its derivatives was revealed when pruned (379 μg/g crude extract) and unpruned samples (247 μg/g crude extract) were compared. In conclusion, antioxidant capacities of pecan can be greatly boosted by mechanical pruning, even at a triannual frequency. The outcomes of this experiment provide pecan growers with cost-effective options to improve both nut productivity and human health promoting components in kernels.

Specified Source(s) of Funding: USDA-NIFA-SCRI Award No. 2011-51181-30674

11:45–12:00 PM

Field Evaluation of Sixteen Rootstocks for Almonds Grown in Heavy Soil and Irrigated with Water High in Sodium, Chloride and Boron

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Almond (P. dulcis) acreage has approximately doubled in California during the past twenty years and now totals about 1.1 million acres. As traditional orchard land is becoming scarce, many new almond orchards are being planted in marginal soils and are irrigated with water considered to be too high in sodium, chloride and/or boron for maximum production using traditionally-used peach rootstocks such as Nemaguard and Lovell. A field trial was planted in 2011 on the west side of the San Joaquin Valley to evaluate sixteen commercially-available rootstocks budded to the almond scion ‘Nonpareil’. The soil is a Zacharias clay loam (pH 7.6, 0.5 ppm boron, 12.1 meq/L Na, 14.1 meq/L Cl, EC = 2.96 dS/m) and the trees are irrigated with ground water marginally high in salt (adjusted SAR = 8.80, 8.90 meq/L chloride, 0.84 mg/L boron). Rootstocks tested included Lovell & Nemaguard (P. persica), Empyrean 1 (a.k.a. Barrier 1) & Avimag (P. persica x P. davidiana), Rootpac R (P. cerasifera x P. dulcis), Krymsk 86 (P. cerasifera x P. persica) and several hybrids of peach and almond (Hansen 536, Brights 5, BB106, GF 677, Floradaguar x Alnem, PAC9908-01, Hansen x Monegro (HM2), Viking and Atlas. Leaves sampled from non-bearing spurs of fourth-season trees indicated that Lovell rootstock had the highest concentration of chloride (0.73%) (P < 0.05), followed by Krymsk 86 and Nemaguard (0.65% and 0.43%, respectively). The critical maximum level for chloride in July-sampled almond leaves is 0.3%. HM2, Floradaguar x Alnem, GF 677, BB106, Brights 5, Hansen, Rootpac R and Viking had the lowest leaf chloride (0.18% to 0.25%). Lovell rootstock also had the highest concentration of boron in the hulls at harvest (180 ppm) while BB106, FxA, Brights 5, PAC9908-01 and Viking had the lowest hull levels of boron (102–109 ppm). The largest trees as measured by trunk circumference
were PAC 9908-01, Empyrean 1 and Flordaguard x Alnem. The smallest trees were Krymsk 86, Cadaman, Lovell and GF 677.

*Specified Source(s) of Funding:* Almond Board of California, University California Cooperative Extension, Bakersfield, CA

12:00–12:15 PM

**Hazelnut Pollinizers Affect Kernel Characteristics in European Hazelnuts (Corylus avellana)**

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Hazelnuts (Corylus sp.) are self-incompatible, monoecious, and wind-pollinated. They typically bloom in the winter and have cold hardy pistillate (female) flowers; however, their staminate (male) flowers can be damaged by freezing temperatures—especially following winter warm spells. This is most pronounced in the commercial European species, C. avellana. Thus, a lack of cold-hardy pollenizers in a C. avellana orchard could lead to limited pollen production and low nut yields in regions with fluctuating winter temperatures. Interestingly, catkins of the wild American species C. americana and American x European hybrid selections have been found to have cold-tolerant catkins. Thus, despite poor nut characteristics, they have been considered for use as pollenizers in European hazelnut orchards to overcome frost damage issues. However, limited testing has been done to determine the effects of American and American x European hybrid pollen on the kernel characteristics of European cultivars. In March 2015, controlled crosses were made in duplicate between three European hazelnut mother trees (‘Yamhill’, ‘Santiam’, and H3R07P25) and six pollen parents (two Americana accessions, 2 Americana x European hybrids, and two European cultivars). All hazelnuts were harvested in August 2015, counted, dried, and a subset of 50 nuts was cracked out from each sample and evaluated. A subset of 20 kernels, rated as good, were then evaluated for sphericity, kernel weight, and kernel to percentage. The percentages of “good” kernels and averages for sphericity, kernel weight, and kernel percentage were analyzed across all crosses. A Fishers LSD test (P ≤ 0.05) was run to determine if pollenizer and pollenizer x mother plant had a significant affect for each dependent variable. When the effects were found to be significant for a variable, pairwise comparisons of means were made within each mother plant. Results showed no seeds were set when using either American hazelnut parent as a pollenizer across all three European mother trees. However, similar seed set was found between the hybrid and European pollen parents. The data analysis showed significant differences between pollen sources in respect percentages of “good” kernels (freedom from defects). Thus, our preliminary results, based on this limited pool of parents, suggest wild American hazelnuts may have compatibility issues with European species. However, the American x European hybrid pollen parents tested resulted in similar seed set, nut and kernel characteristics as the European species and may prove to be useful, cold-hardy pollenizers.

*Specified Source(s) of Funding:* New Jersey Agricultural Experiment Station and Rutgers Center for Turfgrass Science

12:15–12:30 PM

**Lack of Chill Influences Flower Development and Carbohydrate Content of Pistacia vera Spp.**

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Maciej Zwieniecki
University of California, Davis, Davis, CA

Louise Ferguson
University of California, Davis, Davis, CA

In 2015, pistachio (Pistacia vera) production in California’s Central Valley dropped by over 50% compared to previous years. Warm winter temperatures and therefore decreased dormant chill were possible factors for the erratic bloom, poor fruit set and resulting low yield. How well pistachio flowers develop in warm winter regions has not been well investigated. Our research is assessing the development of pistachio flower development under low chill conditions. We are assessing both anatomical structures and floral organ activities; i.e. pollen and ovules. The variation of carbohydrate content in proximal twig sections individual flower buds with low dormant chill will also be evaluated. From mid-February, 15 cm twig sections at least 8cm in diameter with more than 3 floral buds/flowers 5 cm apart have been collected from both south and north facing trees canopies in both female (Kerman) and male (Peters) cultivars. Samples from the high-chill orchards are the control. The biweekly sampling will be continued through fruit set.Twig carbohydrate content will also be measured to determine if chill affects respiration and therefore final carbohydrate content and bloom quality.

12:30–12:45 PM

**Twenty-eight Years of Pistachio Improvement**

Dan Parfitt*
University of California, Davis, CA

Craig Kallsen
University of California Cooperative Extension, Bakersfield, CA

Joseph Maranto
University California Cooperative Extension, Bakersfield, CA

A discussion of pistachio breeding and genetics activities at the University of California, Davis, over the 28 years of our project is presented. The project was initiated in 1988–89 by Dan E. Parfitt and Joseph Maranto, with the objective of developing...
improved cultivars for California growers. Craig Kallsen joined the project after Joseph Maranto’s retirement. Approximately 6900 seedlings from 438 crosses were tested at 3 California central valley locations. Twelve accessions were selected for advanced trials and an additional 117 items were retained for later evaluation. Genetic analysis of phenological traits was conducted by C.T. Chao in the 1990s. N. Arjmand helped develop disease screening protocols for Botryosphaeria dothidea. Two of the female advanced selections were released as ‘Golden Hills’ and ‘Lost Hills’, along with a male cultivar ‘ Randy’. These cultivars have been well received by the industry due to their earlier harvest, good yields, high split percentage, few blank nuts, and less Navel Orangeworm damage. We estimate that more than 30,000 acres of ‘Golden Hills’ and ‘Lost Hills’ have been planted since release in 2006–07. We have continued to make new cross combinations with an emphasis on expanding the harvest season, reducing tree chilling requirements, increasing scion vigor, and improving nut quality. An earlier harvest female is being released in 2016, along with 2 males for better pollenization of both new and existing cultivars.

Specified Source(s) of Funding: California Pistachio Commission, California Agricultural Experiment Station, UC Davis

Oral Session—Undergraduate Student 2

Moderator: Stephanie Burnett
University of Maine, Orono, ME

11:30–11:45 AM

Risk Mitigation through Holistic Sustainable Horticultural Production Practices: The Case of Poultry in Northern Mozambique

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With a rapidly growing population and arable land decreasing, sustainable agriculture is vital to managing the already depleted resources in Northern Mozambique to ensure food security. Research in Mozambique has shown that poultry producers have a desire to increase income stability through diversification of farming practices to smooth revenue over time. In low-income countries, agricultural diversification can lead to a reduction of income variance and thus contribute to the well being of impoverished producers. This research focuses on the most efficient method for implementing sustainable best practices (BPs) for crop production systems to supplement and improve the income of poultry producers who currently depend on the volatile poultry market for all of their income. Objectives for the project include: 1) construct guidelines for horticultural BPs prior to arrival, 2) perform on site evaluations, make adjustments to guidelines, and analyze the income data sets of poultry growers, 3) perform demonstrations in Mozambique that will educate those involved in the poultry industry based on the proposed BP guidelines, and 4) provide areas for future research. Research conducted on soil management and composting techniques interconnect with the poultry production by-products to save on off-site inputs. Most importantly for the impoverished poultry producers in Mozambique the most expensive input of vegetable production, fertilizer, is a free by-product from poultry production. The results from this research can be used to reduce risks associated with poultry production in the United States and provide BPs for recycling by-products of the industry. Specifically, given that large poultry producers have begun to start contracting with poor agricultural producers in the rural Mississippi Delta region, this template can act as a risk management springboard for poultry growers in the rural south. This case study serves as a model for future research and aims to gain a deeper understanding of holistic horticulture approaches.

Specified Source(s) of Funding: University of Arkansas Honors College, University of Arkansas Dale Bumpers College Creative Research Grant, SURF Research Grant

11:45 AM– 12:00 PM

The Effects of 1-Methylcyclopropene on Botrytis cinerea infection of Petunia xhybrida Flowers in the Postharvest Environment

Jared Jent*
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Uttara Samarakoon
The Ohio State University, Wooster, OH

James Faust
Clemson University, Clemson, SC

Botrytis cinerea rapidly infects petunia flowers in the postharvest environment. Previous research suggests that pollination is the initial event that causes the rapid flower decay. Self-pollination occurs on petunia when flowers are shaken in the post harvest environment during handling and transport to market. This suggests petunias treated with the ethylene-action inhibitor, 1-methylcyclopropene (1-MCP) prior to shipping can reduce the phenomenon known as flower petal meltdown. An experiment was conducted to determine the effect of 1-MCP on petunia flower senescence. The 2 x 2 factorial experiment consisted of petunia flowers that were hand-pollinated, or not pollinated, and then treated with 1-MCP or left untreated, for 24 hours. The flowers were then placed in a chamber with 99% humidity and inoculated with a conidial suspension of botrytis. Disease incidence data were collected at twelve-hour intervals for 72 h. Flowers were scored using a 1–9 scale based on disease progression, with 1 = minimal necrosis and 9 = complete loss of

An asterisk (*) following a name indicates the presenting author.
tissue integrity. The non-inoculated control (no pollination and no 1-MCP treatment) had the lowest disease severity of 1.9 at 48 h, while the inoculated, pollinated, no 1-MCP treatment had the highest disease severity rating of 7.2. The 1-MCP treatment of pollinated flowers had a significantly lower disease severity rating (3.6) than the non 1-MCP-treated plants. Non-pollinated flowers, with or without 1-MCP, were not significantly different from pollinated flowers treated with 1-MCP. These results suggest than the phenomenon of petunia flower meltdown in the postharvest environment is initially caused by pollination, and 1-MCP is effective at reducing the rate of flower senescence. Also, botrytis infection of the flower petals results in a further increase in the rate of flower senescence regardless of pollination and 1-MCP treatments.

Specified Source(s) of Funding: American Floral Endowment

12:00–12:15 PM

The Development and Use of SSR Markers for Penstemon scariosus, a Species with Horticultural Potential

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USDA-ARS, Forage and Range Research Laboratory, Logan, UT

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Penstemon scariosus var. scariosus is horticulturally interesting because of its rather large showy blossoms, and its attractive emerald to dark green and somewhat compact foliage found in plants from some accessions. Furthermore, this perennial plant has potential in xeric urban landscapes of the western United States because it flourishes in arid and desolate environments at higher altitudes. Finally, P. scariosus var. albiflavis is being considered for listing under the Endangered Species Act of 1973 due to recovery of hydrocarbon deposits located at sites where this variety is almost exclusively found. Thus, the horticultural potential of var. scariosus and the rarity of var. albiflavis underlie the importance of understanding of the phylogenetic relationship within P. scariosus. To do so, we developed a set of ten new SSR (simple sequence repeat) markers specifically to study this species. These markers were identified using a genomic reduction protocol in combination with next-generation sequencing of P. scariosus. Besides these ten markers, we tested all previously reported Penstemon SSRs and identified six additional markers that were robust, reliable, and polymorphic across a subset of 27 accessions including all four varieties of P. scariosus and eight closely related taxa. Of these 16 markers we selected ten that combined well together when labeled with either NED (yellow), 6-FAM (blue), or HEX (green) utilizing the ABI 3730xl with Gene Scan 500 ROX Size Standard. We utilized those ten markers to test the individual samples of our collected 76 accessions. The results of this study indicate that one taxon (P. fremontii var. glabrescens) is genetically distinct from P. fremontii and was elevated to its own species. Additionally, our data suggests that P. scariosus var. albiflavis is genetically independent and unique compared to the rest of the P. scariosus varieties. The intraspecific phylogenetic relationships morphological distinction of three remaining varieties of P. scariosus (var. cyanomontanus, garrettii, and scariosus) are less clear.

Specified Source(s) of Funding: Brigham Young University Plant and Wild Life Department, and BLM grant L14AC00346

12:15–12:30 PM

Subcellular Localization of Fern Glutaredoxin

PvGrx5 in Transgenic Arabidopsis thaliana

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Arsenic is a toxic element to most living forms however, there are plants such as the fern Pteris vitata, which can accumulate large amounts of arsenic without compromising its growth, and thus, constitute an important resource to understand the mechanisms of arsenic tolerance, as well as, a source of genetic material for crop improvement. Previous work on P. vitata identified a glutaredoxin, named PvGrx5, whose expression in both bacteria and plants resulted in an increased tolerance to arsenic. Out of the two putative catalytic motifs of PvGrx5, CRSS and CGFS, mutagenesis analysis identified the first motif, particularly the cysteinyl residue (Cys67), to be important for conferring arsenic tolerance. However, bioinformatics analysis indicated that PvGrx5 is a chloroplastic protein with a transit peptide of 69 residues, thus suggesting that Cys67 would be lost upon translocation of the protein into the chloroplast. To verify the subcellular localization and to solve the issue regarding the length of the transit peptide, sequences coding for the full length PvGrx5 or for two predicted transit peptides were fused to a green fluorescent protein (GFP) tag and expressed in transgenic Arabidopsis. Confocal microscopy revealed that full-length PvGrx5 fused to GFP, as well as, the transit peptide of 69 residues fused to GFP were located in the chloroplast. A smaller transit peptide of 44 residues fused to GFP, was localized in the mitochondria, verified using MitoTracker dye for the identification of the organelle. The implications of these results in understanding the functional role of this glutaredoxin will be discussed.

An asterisk (*) following a name indicates the presenting author.
**Sweetpotato Storage Root Yield As a Function of Plant Age**

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Don LaBonte
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Bob Mirabello
Louisiana State University AgCenter, Baton Rouge, LA

Sweetpotato (*Ipomoea batatas* L. (Lam.)), is commercially propagated by stem cuttings from shallow storage root beds. Once cut, new plants arise from nodes of residual stems in the bed and allow for multiple cuttings in a season. The plants arising from the storage roots continue to grow at the apex and growers routinely clip the top growth by mowing so uniform sized plants are maintained for transplanting. Plants are normally cut when reaching 25 cm, but rain may delay transplanting by weeks and beds are topped multiple times. Growers express concern that older transplants may perform poorly in comparison to new growth transplants. ‘Orleans’ variety transplants of varying type and age (new growth, second cuttings, and plants topped over 4 weeks) were compared to determine if transplant age effects storage root yield and quality by grade. Results showed no statistical difference between older transplants and new growth transplants for three grades of sweetpotato and total marketable yield.

**Oral Session—Ornamental Plant Breeding 1**

Moderator: Lisa Alexander
USDA–ARS, McMinnville, TN

**Irradiation of *Acer buergerianum* with Cobalt-60 for Sterility Breeding**

Andrew Payton*
University of Georgia, Athens, GA

*Acer buergerianum* Miq., commonly referred to as trident maple, is a commercially important ornamental landscape tree in the United States. These apparently self-incompatible trees do not set seed when planted in isolation. When two different genotypes of *A. buergerianum* are planted in close proximity, seed set becomes extremely problematic due to the tremendous proliferation of seed and their ability to disperse, germinate, and thrive in the landscape. For these reasons sterility is a highly desirable trait. No sterile cultivars have been developed for this species as of 2016. A common method for obtaining sterility in a population is genetic mutation via irradiation. This study examined dosage effects of Cobalt-60 (60Co) on *A. buergerianum* by examining treatments at four irradiation levels: an un-irradiated control, 50 grays (Gy), 100 Gy, and 150 Gy. After normalizing with data obtained from the control, seedling survivability for 50 Gy, 100 Gy, and 150 Gy treatments was 86%, 85%, and 56%, respectively. We are continuing to monitor the M1 population in order to observe differences in growth indices among treatments. Seedlings will be tracked until reaching sexual maturity and then screened for sterility and novel phenotypes.
Evaluation of *Rosa palustris* As a Parent for Breeding Rose Rosette Disease-resistant Roses

Ellen Roundey*
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Rose rosette disease (RRD) is a viral disease of the genus *Rosa*, causing plant death in 2–4 years. No cultivars have been confirmed to be resistant and no consistently effective control methods exist, making the breeding of resistant rose cultivars a priority. To this end, we investigated the usefulness of *Rosa palustris* Marsh., a species reported resistant to RRD though seldom used in rose breeding, as a parent in breeding for RRD resistance. *Rosa palustris* was crossed with various cultivars chosen either for their reported resistance to RRD or for their past success as breeding parents. Additionally, crosses were made between these cultivars for a total of 90 unique crosses. Success of crosses was determined by hip set, seed production and germination rates. *Rosa palustris* was most successful as a parent when used as a male; however, most crosses with *R. palustris* still resulted in high flower abortion. Embryo rescue was performed on select *R. palustris* crosses but with limited success. We suggest this is due to the wide nature of these crosses, as *R. palustris* is in section Caroliniae while most cultivars are hybrids from sections Synstylae and Indicae. While attempts to breed with *R. palustris* will be continued, future breeding will focus on alternative parents, such as reported-resistant *Rosa setigera* (section Synstylae), which may prove more productive.

Production of Polyploid *Hydrangea macrophylla* via Unreduced Gamete Breeding

Lisa Alexander*
USDA-ARS, McMinnville, TN.

*Hydrangea macrophylla* (Thunb.) Ser., florist’s or bigleaf hydrangea, is the most economically important member of the *Hydrangea* genus, which accounted for 73,000,000 in U.S. nursery sales in 2007. Diploid and triploid cultivars exist and *Hydrangea* is the most economically important member of the genus, which accounted for 73,000,000 in U.S. nursery sales in 2007. Diploid and triploid cultivars exist and *H. macrophylla* ‘Trophee’, was previously shown to have a bimodal pollen size distribution, which may be indicative of unreduced gametes. We used *H. macrophylla* ‘Trophee’ as a parent in a series of crosses with other diploid *H. macrophylla* cultivars. The objective of this study was to evaluate five reciprocal full-sibling *H. macrophylla* families for ploidy and phenotype, determine the impact of ploidy on phenotype, and determine the efficacy of unreduced gamete breeding. Diploids, triploids, and a single tetraploid were found in the offspring pool with peak means of 51.2 ± 1.5, 72.7 ± 1.8, and 88.5, respectively. All offspring from crosses with ‘Trophee’ as the female parent were diploid as expected. The full-sibling family with ‘Trophee’ as the male parent contained 94% triploids, supporting the hypothesis that the bimodal pollen size distribution of ‘Trophee’ reflects the presence of unreduced gametes. Diploids and triploids were not significantly different in plant height (P = 0.58), stem width (P = 0.99), or inflorescence size (P = 0.67). The single tetraploid in the offspring pool was significantly shorter (P = 0.025) and had significantly narrower stems (P = 0.038) than the diploids and triploids. Triploids had significantly larger stomata (8.29 ± 1.4 μM²) than diploids (5.5 μM²) or tetraploids (6.0 μM²), where tetraploids had a higher number of stomata per unit area (144) compared to diploids (76 ± 24) and triploids (45 ± 16, P < 0.001). These results establish a link between ploidy and phenotype in plants of similar genetic background and support the efficacy of unreduced gametes in polyploidy breeding. We also report the first production of a tetraploid *Hydrangea macrophylla* using traditional controlled pollination breeding.

Oral Session—Vegetable Breeding

Moderator: Carlos Avila
Texas A&M AgriLife, Weslaco, TX

1:45–2:00 PM

Early Arrival and Adoption of *Cucurbita* (Pumpkin, Squash) in Renaissance and Post-Renaissance Italy

Teresa A. Lust
Dartmouth College, Hanover, NH

Harry S. Paris*
Agricultural Research Organization, Ramat Yishay, Israel

Pumpkins, *Cucurbita* species, are native to the Americas and were introduced to Europe shortly after 1492. By 1518, *Cucurbita pepo* L. and *C. maxima* Duchesne had arrived in Italy, and within several decades were adopted in Italian cookery for use of both young and mature fruits. By the early seventeenth century, round and elongate young fruits of *C. pepo* had entered Italian kitchens as separate culinary items, and the latter soon largely replaced the longstanding culinary use of young, elongate bottle gourds, *Lagenaria siceraria* (Mol.) Standl. By the eighteenth century, the long-fruited cocozelle squash, *C. pepo* subsp. *pepo* Cocozelle Group, had become established in the environs of Naples. A particular extant cocozelle, ‘San Pasquale,’ named after a Neapolitan neighborhood, was known by 1811. The *C. pepo* subsp. *pepo* Zucchini Group originated in the environs of Milan around 1850, as evidenced by similar descriptions of the “zucca verde quarantina” in an agricultural book from 1855 and the “zucca quarantina vera nana” in a horticultural book from 1892. The “nana di Milano” in the 1891 seed catalogue of Fratelli

An asterisk (*) following a name indicates the presenting author.
Ingegnoli also likely refers to the zucchini. The word *zucchini* in reference to squash and the *C. pepo* cultivar-group Zucchini originated independently but nearly concurrently. The earliest appearance of the word “zucchini/e” in literature that we found dates to a Tuscan botanical dictionary of 1809, in reference to small, mature dry bottle gourds, *L. siceraria*, used for storing tobacco. By 1844, the term appeared in Tuscan cookbooks to indicate culinary fruits of *C. pepo*. Use of the word “zucchini” spread across northern Italy during the second half of the nineteenth century, entering the Standard Italian lexicon by 1875, and gradually displacing older dialect terms, such as “zucchette” and “zucchettine,” which had been in use regionally for various young squash. Today the word “zucchini” is used in Italy much as the term “summer squash” is used in American English. “Zucchini” was applied in the United States to a uniformly cylindrical, intensely colored squash that had been imported from Milan not long before 1918. In the United States and elsewhere outside of Italy, the word “zucchini” then came to signify exclusively uniformly cylindrical, intense-colored squash.

**Specified Source(s) of Funding:** Lillian Goldman Charitable Trust (New York)

2:00–2:15 PM

**Ground Jewel™ and Ground Dew™ Are Two New Tomato Inbred Lines for Growers in the Northern and Short-season Locations**

Ryan Murphy  
University of Minnesota, St. Paul, MN

Duane McDowell  
University of Minnesota, St. Paul, MN

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

Ground Jewel™ and Ground Dew™ are two new dwarf tomato cultivars with determinate growth habits. Fruit production is relatively high for the mature size of the plant where the fresh fruit accounts for on average 87% for Ground Jewel™ and 84% for Ground Dew™ of the total plant weight at harvest. Both cultivars are the result of an initial cross between Zac-Heart™ and MicroTom in 2008. Successive generations were selected for high fruit yield, short time to maturity, dwarf plant structure, and stable phenotype. Plants from these two cultivars can be spaced one foot on center from each other and still achieve maximal yield. Ground Jewel™ and Ground Dew™ are attractive varieties for both commercial producers and home gardeners, especially those residing in regions with short growing seasons. Ground Jewel™ and Ground Dew™ are the first two cultivar releases from the University of Minnesota Tomato Breeding Program. The main goals of this program are breeding cold hardy short season tomato varieties that appeal both to commercial growers and home gardeners residing in colder climates with short growing seasons.

**Specified Source(s) of Funding:** Minnesota Agricultural Experiment Station

An asterisk (*) following a name indicates the presenting author.
nacearum (Lso), the causative agent of economically important plant diseases in Solanaceae species including the tomato vein-greening and potato zebra chip. The appearance of TPP-Lso in potato, tomato, and pepper fields has resulted on millions of dollars in losses. As a result, in the absence of commercial resistant cultivars to both the vector and the pathogen, growers have dramatically increased pesticide use to control the vector. In tomato (Solanum lycopersicum), resistance against the insect vector has been recently reported in wild relative specie S. habrochaites. The objective of this project was to characterize S. habrochaites based resistance to ultimately introgress it into cultivated tomato. In order to study inheritance and characterize resistance, the backcross recombinant inbred lines representing the genome of S. habrochaites accession LA17777 in S. lycopersicum background were obtained from the Tomato Genetics Resource Center at UC-Davis and screened for adult mortality and fecundity. The introgression lines consist of a core set of 57 lines that provide good genome representation with a minimum number of segments in each line. The RIL, susceptible tomato cultivar, MoneyMaker, and resistance source S. habrochaites LA17777 were infested with two adult males and two females in a no-choice test using clip cages. Adult survival and fecundity (total number of eggs and nymphs) was recorded 10 days after. No live adults and nymphs were found in LA17777, and only 3 eggs were found in one of the replicated plants. Unfortunately, no single RIL showed the same level of resistance as the source. However, lower fecundity and survival as compared to susceptible control was observed in seven RILs, suggesting that resistance in LA17777 involves more than one gene. Four of those RILs had overlapping chromosome introgressions on chromosomes 5 and 8, therefore it was concluded that at least five introgressed segments located in chromosomes 2,3,5,6, and 8 contributed to resistance. Furthermore, the resistance factor on chromosomes 2 appear to contribute to reduced fecundity but does not affect survival, while segments in chromosomes 3, 5, and 8 contribute to both adult increased mortality and lower fecundity. Finally, introgression on chromosome 6 contributes to adult increased mortality, however, a higher number of eggs were observed. Identified introgression lines carrying resistance factor(s) will be crossed with advanced tomato breeding lines to develop resistant population(s).

2:45–3:00 PM

Heritability Analysis for Heat Stress Tolerance in Tomato (Solanum lycopersicum L.)

Dilip Panthee*
North Carolina State University, Mills River, NC

Jonathan Kressin
North Carolina State University, Raleigh, NC

Ann Piotrowski
North Carolina State University, Mills River

The growing evidence of global warming and, its potential impact on crop production has prompted several physiological and genetical analyses under high temperature conditions. Optimum growing temperatures for tomato (Solanum lycopersicum L.) are less than 32 °C and 24 °C during day and night, respectively. Tomato is grown in subtropical and tropical regions of the world, where day and night temperatures exceed the optimum temperatures during summer, which exerts potential heat stress on tomato production. With looming global warming, the temperature levels may go up even further. The objective of the present study was to estimate the heritability of the flower and fruit setting ability of tomato populations under heat stress conditions so that its improvement for these traits can be planned. We developed the multiple tomato populations using parents from heat tolerant lines, and heat sensitive lines from North Carolina State University tomato breeding program as well as AVRDC sources. The F2 and F2,3 populations were grown at Piedmont Research Station, NC, where summer growing temperatures are higher than optimum for tomato production. Heritability estimates of one of the populations (NC10418; 230 HS-1(99) x NC 1CS) by regression analysis of off-spring on parents method for number of flowers per cluster, number of fruit set per cluster and fruit set index were 72%, 49%, and 60%, respectively. We will also present results from other populations. There was a positive correlation (r = 0.50, P < 0.05) between number of flowers and number of fruit set per cluster, which was in close agreement with the past findings. These findings may be useful to investigate the genetic control of heat stress tolerance in tomato and make crop improvement in future.

3:00–3:15 PM

Using Genotyping-by-sequencing to Develop Broccoli Markers for Construction of a High-density Linkage Map and to Identify QTL Associated with Heat Tolerance

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Cornell University, Ithaca, NY

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Heat stress reduces the yield and quality of broccoli heads imposing seasonal and geographic limits to broccoli production. For the most part, the risk of producing broccoli with head defects (uneven beads, bracts in heads, etc.) induced by high temperatures has restricted commercial production in the United States to western environments in which temperatures are not usually expected to exceed 25 °C to 28 °C. Heat tolerant broccoli breeding lines have been developed by the USDA Agricultural Research Service to facilitate year-round broccoli production along the eastern coast of the United States. To dissect the genetic basis of this tolerance of non-optimal, high temperatures, a doubled haploid mapping population (N = 156) was developed for QTL mapping. Genotyping-by-sequencing produced 1435
high-quality SNPs that formed 9 linkage groups. Multiple QTL mapping found four QTL and one epistatic interaction that explained 57.5% of the population variation for heat tolerance. Three markers tightly linked to the significant QTL can be used for marker-assisted selection in future breeding efforts using the developed tolerant lines.

**Specified Source(s) of Funding:** National Institute of Food and Agriculture (NIFA) project no. 2010-51181-21062, Specialty Crop Research Initiative; United States Department of Agriculture (USDA) project no. 6080-21000-018-00

3:15–3:30 PM  
**Relationship of the I-3 Gene for Resistance to Fusarium Wilt Race 3 with Resistance to Races 1 and 2 in Tomato**  
Samuel F. Hutton  
University of Florida, Wimauma, FL  
Jian Li  
University of Florida, Wimauma, FL  
Jessica Chitwood*  
University of Florida, Wimauma, FL

Fusarium wilt is a major soil-borne disease of tomato in many production regions throughout the world. Disease management is primarily achieved by deployment of the dominant, race-specific resistance genes, I-1, I-2 and I-3 for control of races 1, 2 and 3, respectively. I-3 was introgressed from *Solanum pennellii*, and the introgression in early breeding materials conferred resistance to races 1 and 2 as well. However, resistance to these races is reportedly not conferred by the I-3 gene, but by the linked genes, I1 and a putative race 2 resistance gene. Recent studies have shown that the I-3 locus is negatively associated with several horticultural traits, and there is evidence that some of these problems result from linkage drag. Whereas the development and deployment of a reduced introgression may resolve these horticultural issues, it may also have the unintentional effect of dissociating the I-3 gene from race 1 and race 2 resistance. A map-based cloning approach was used to fine-map the I-3 gene to an approximately 30 Kb interval. Four recombinants with reduced introgression sizes, two lacking the *S. pennellii* introgression above the I-3 interval, and two lacking the introgression below this interval, were backcrossed to the Fusarium wilt susceptible cultivar, Bonnie Best. For each recombinant, BC$_1$F$_2$ populations were used to investigate the location of I-1 and the putative race 2 gene relative to I-3. Results from race 1 inoculations indicated that the I1 gene is likely located outside the 4 Mbp introgression which is present in most modern cultivars and spans from 60 to 64 Mbp on the SL2.50 genome assembly. For all four recombined introgressions, Fusarium wilt race 2 inoculations indicated that the putative resistance gene is located within the 30 Kb I-3 interval. This suggests that race 2 resistance is conferred either by I-3 or by a very tightly linked allele. Implications of these findings on future research and breeding strategies will be discussed.

An asterisk (*) following a name indicates the presenting author.
were to isolate an HsfA2 gene (CtHsfA2b) from a warm-season grass species, African bermudagrass (Cynodon transvaalensis Burtt-Davy), and to determine the physiological functions and transcriptional regulation of HsfA2 for improving heat tolerance. Gene expression analysis revealed that CtHsfA2b was heat-inducible and exhibited rapid response to increasing temperature. Ectopic expression of CtHsfA2b improved heat tolerance in Arabidopsis and restored heat-sensitive defects of Arabidopsis hsfA2 mutant, which was demonstrated by higher survival rate and photosynthetic parameters, and lower electrolyte leakage in transgenic plants compared to the WT or hsfA2 mutant. CtHsfA2b transgenic plants showed elevated transcriptional regulation of several downstream genes, including those encoding ascorbate peroxidase (AtApx2) and heat shock proteins [AtHsp18.1-C1, AtHsp22.0-ER, AtHsp25.3-P and AtHsp26.5-P(r), AtHsp70b and AtHsp101-3]. CtHsfA2b was found to bind to the heat shock element (HSE) on the promoter of AtApx2 and enhanced transcriptional activity of AtApx2. These results suggested that CtHsfA2b could play positive roles in heat protection by up-regulating antioxidant defense and chaperoning mechanisms. CtHsfA2b has the potential to be useful as a candidate gene to genetically modify cool-season species for improving heat tolerance.

2:15–2:30 PM

**Light Regulation of Arabidopsis PIRN1 Indicates Functions in Environmentally-induced Stress Physiology of the Seedling**

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Carlos Montero
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Katherine Warpeha
University of Illinois at Chicago, Chicago, IL

Plants develop various ways to accommodate a continuously changing environment. In response to light and hormones, a cupin superfamily member Pirin1 (PRN1), acts as a transcriptional activator, as well as an enzyme that can cleave the UV-induced and UV-screening compound quercetin (flavonoid). Our lab recently published findings that indicate that Pirin1 (PRN1) in Arabidopsis thaliana is critical for seedlings to orient and respond to light in the seed-to-seedling transition. The pool of flavonoids in the seedling is regulated by PRN1 activity, and PRN1 is expressed in a tissue specific manner depending on developmental state. Based on genetic studies of mutant and transgenic (complementation and overexpressors) seedlings, PRN1 directs organ and overall hypocotyl growth of the young seedling. Human pirin (hPir) was transformed into prn1 Arabidopsis mutants. We evaluated plant-specific and non-plant specific responses/activities for ability of hPir to rescue defects of prn1 under a number of abiotic signals that in excess can be stressors. We report that PRN1 is critical for proper response to abiotic signals in general and plays a role in the leaves and root in how the seedling is able to respond to the environment. In addition, light plays a major role in permitting PRN1 to play a role in responding to the abiotic signals in the environment. PIRINs hence, may be excellent targets for improving responses to stress in plants of economic importance.

*Specified Source(s) of Funding: NSF*

2:30–2:45 PM

**Single-cell Type Proteomics for Studying Stress-induced Pollen Infertility**

Suping Zhou
Tennessee State University, Nashville, TN

Hui Li
Tennessee State University, Nashville, TN

Yingde Zhu*
Tennessee State University, Nashville, TN

Sarabjit Bhatti
Tennessee State University, Nashville, TN

Ted Thannhauser
USDA, Ithaca, NY

Crop production has been experiencing a significant loss to abnormal air and soil conditions, which caused by global warming and climate changes. Tomato is a major crop worldwide and pollen development is the most sensitive to environmental stress among the biological processes affecting plant productivity. Thus tomato pollen development is a good model to monitor the more sensitive process and will assume a decisive role in causing yield reduction as weather gets increasingly hotter. In this study, it will determine precisely the timing and the effects of heat stress on the final fate of pollens, which is the essential step for exploring the underlying mechanisms. Tomato ‘Money Maker’ will be grown in a glasshouse at day/night temperature of 26 °C/22 °C with natural illumination. Flowers will be tagged on the first sight of emergence. The process will continue daily for 15–20 days until we get at least 50 each of microsporocytes, meiosis, dyads, tetrads and free microspore. Then the plants will be transferred to three temperature regime chamber: day/night temperatures of 32 °C/26 °C, 38 °C/26 °C for high condition, and 26 °C/22 °C as control. Anthers will be collected and examined under a microscope for the presence or absence of pollens; treated pollens will be under in vitro viability test and the results will determine the heat treatments for inducing non-viable pollens or non-germinable pollens; in addition, treated pollens will be

An asterisk (*) following a name indicates the presenting author.
tested for pollinating tomato flowers to determine if heat treatment induce in vivo nonfunctional pollens.

2:45–3:00 PM

**Photosynthesis Response of Tomato Plants Subjected to Drought Treatments That Differed in the Rate but Not Severity or Duration of Exposure to Drought Stress**

Krishna Nemali*
Purdue University, West Lafayette

Marc van Iersel
University of Georgia, Athens, GA

Photosynthesis is highly sensitive to the rate, duration and severity of drought stress. The objective of this study is to understand acclimation of photosynthesis to two drought stress treatments that differed only in the rate of exposure to drought stress. Tomato (*Solanum lycopersicum* L.) plants were subjected to different rates of exposure to drought stress either by maintaining substrate moisture content (θ) at a low level (WL1) or allowing θ to dry down from a higher to lower θ level (WL2). The average severity (θ = 15%) and duration (2 weeks) of the drought stress was similar between two treatments. An automated irrigation controller interfaced to ECH2O moisture sensors was used to accurately maintain the two drought treatments. Measurements included leaf photosynthesis rate (A), stomatal conductance (gs), quantum yield of photosystem II (ΦPSII), relative electron transport rate (ETR), and response of leaf photosynthesis to internal CO₂ concentration (A-C response curves). Leaf A and gs did not change in the WL1 treatment, whereas they decreased linearly in the WL2 treatment over time. Both ΦPSII and ETR were not statistically different between WL1 and WL2, indicating that light reactions of photosynthesis were largely unaffected by the rate of exposure to drought stress. However, mesophyll conductance to CO₂ and Rubisco efficiency determined from the A-C response curves were lower in the WL2 than WL1 treatment indicating that rate of drought stress mostly affected Calvin cycle of photosynthesis. These results support that the acclimation of photosynthesis to drought stress was more pronounced in WL1 than WL2 treatment, likely due to prolonged exposure to a similar rate of drought stress in WL1.

3:00–3:15 PM

**Effects of Applying Hydrogen Peroxide on Phosphorus Uptake and Adhase Activity of Flooded Snap Bean Roots**

Danyang Liu*
University of Florida, Gainesville, FL

David Liu
University of Florida, Gainesville, FL

Anna-Lisa Paul
University of Florida, Gainesville, FL

Kelly Morgan
University of Florida, Immokalee, FL

Huangjun Lu
University of Florida, Belle Glade, FL

Flooding is one of the major abiotic stresses for vegetable production in Florida due to heavy rains and hurricanes, etc. There are few effective solutions to flooding or hypoxic stresses snap bean production has to face. We hypothesized that application of oxygen fertilizer/oxygen enrichment may increase nutrient uptake of snap bean and minimize economic loss caused by flooding. This study was hydroponically conducted in greenhouse to evaluate the effects of oxygen fertilization on biochemistry and physiology of flooded snap bean. Ten percent of Hoagland solution was used to grow the snap bean seedlings in 1500 mL containers. There were three treatments: 1) control without either aeration or oxygen fertilization; 2) aeration with an air pump; and 3) oxygen fertilization by using 3% hydrogen peroxide. The measurements were completed at the first trifoliate growth stage. Phosphorus (P) uptake rates were determined by using an AQ2 Discrete Analyzer. Alcohol dehydrogenase (ADH, EC 1.1.1.1) of flooded snap bean root tips was calorimetrically analyzed at 340 nm. The P uptake rates were 0.47, 0.82, and 0.76 mg/plant/hour for Treatments 1, 2, and 3, respectively. Treatments 2 and 3 both had significantly greater P uptake rates than Treatment 1 but there was not any significant difference between the uptake rates of Treatments 2 and 3. The respective ADH activity was 12.24, 0.89, and 1.25 nmol NADH min/mg protein for Treatments 1, 2, and 3. These results showed that oxygen fertilization significantly improved flooded snap bean’s biochemical and physiological status. Therefore, oxygen fertilization may provide a new solution to alleviate flooding or hypoxic stresses for snap bean production but more research is needed.

3:15–3:30 PM

**Variation in Salt Tolerance Among Genetically Diverse Lines of Cultivated Sunflower (*Helianthus annuus* L.)**

Caitlin D.A. Ishibashi*
University of Georgia, Athens, GA

John M. Burke
University of Georgia, Athens, GA

High salinity levels constitute a major concern in agricultural settings, especially in irrigated fields, with an estimated 45 million hectares of irrigated land affected. Plants grown under salt stressed conditions may suffer from reduced ability to uptake water, cell turgor loss, cell toxicity, and even eventual whole plant death. Cultivated sunflower (*Helianthus annuus* L.) is an important oilseed and confectionery crop, and its ability to resist salt stress is not well characterized. Therefore, the objective of this study was to screen different genetically diverse accessions of cultivated sunflower for salt tolerance. We hydroponically grew 9 lines of *H. annuus* in a common garden greenhouse environment. We then applied a sodium chloride solution (at either a 100, 200, or 300 μmol concentration of sodium chloride) to the plants at the seedling stage to induce a salt stress. We measured plant growth under these new conditions for several...
Effects of different nitrogen fertilizer rates on southern highbush blueberry (SHB) growth and soil nitrate levels during the first year of plant establishment were studied. One-year-old ‘Emerald’ and ‘Farthing’ liners were planted in April 2015 in pine-bark amended soil and fertilized with 0, 42, 84, 168, or 336 kg N per hectare (0N, 42N, 84N, 168N, 336N, respectively) per year. Fertilizer (UAN-32) was applied through fertigation daily from April through November. Soil cores were collected four times per year for analyses of soil nitrate content at depths of 0.15, 0.3 and 0.76 m. Significantly higher soil nitrate levels were found at all three depths in plots treated with 336 N compared to plots fertilized with lower N rates. Since both SHB cultivars are shallow-rooted, and their roots are mainly located in the top 0.4 m of the soil profile based on the observation, the greater soil nitrate concentration in plots with 336 N at the depth of 0.76 could not be absorbed by plants and thus resulted in nitrogen loss. Based on the measurements throughout the year, nitrogen fertilizer rates did not affect plant height or leaf nitrogen concentration for either ‘Emerald’ or ‘Farthing’. According to the canopy area measured by an image-processing program ImageJ, both cultivars had significantly larger canopies when fertilized at 336N compared with the 0 N, 42 N, and 84 N treatments. Additionally, higher N rates advanced bloom the next season. ‘Emerald’ plants fertilized with 336 N bloomed one, two, or three weeks earlier than those fertilized with 168 N, 84 N, or 42 N, respectively. There was no difference in time of bloom between the 0 N and 42 N treatments. Similarly, bloom on ‘Farthing’ plants fertilized with 336 N or 168 N was advanced by one week compared with the other treatments.

Specified Source(s) of Funding: National Science Foundation

Oral Session—Plant Nutrient Management 1
Moderator: Chiwon W. Lee
North Dakota State University, Fargo, ND

2:00–2:15 PM
Optimizing Nitrogen Fertilizer Rates for Commercial Southern Highbush Blueberry Production during Establishment
Yang Fang*
University of Florida, Gainesville, FL
Jeffrey Williamson
University of Florida, Gainesville, FL
Rebecca Darnell
University of Florida, Gainesville, FL
Yunccong Li
University of Florida, Homestead, FL
David Liu
University of Florida, Gainesville, FL

Effects of different nitrogen fertilizer rates on southern highbush blueberry (SHB) growth and soil nitrate levels during the first year of plant establishment were studied. One-year-old ‘Emerald’ and ‘Farthing’ liners were planted in April 2015 in pine-bark amended soil and fertilized with 0, 42, 84, 168, or 336 kg N per hectare (0N, 42N, 84N, 168N, 336N, respectively) per year. Fertilizer (UAN-32) was applied through fertigation daily from April through November. Soil cores were collected four times per year for analyses of soil nitrate content at depths of 0.15, 0.3 and 0.76 m. Significantly higher soil nitrate levels were found at all three depths in plots treated with 336 N compared to plots fertilized with lower N rates. Since both SHB cultivars are shallow-rooted, and their roots are mainly located in the top 0.4 m of the soil profile based on the observation, the greater soil nitrate concentration in plots with 336 N at the depth of 0.76 could not be absorbed by plants and thus resulted in nitrogen loss. Based on the measurements throughout the year, nitrogen fertilizer rates did not affect plant height or leaf nitrogen concentration for either ‘Emerald’ or ‘Farthing’. According to the canopy area measured by an image-processing program ImageJ, both cultivars had significantly larger canopies when fertilized at 336N compared with the 0 N, 42 N, and 84 N treatments. Additionally, higher N rates advanced bloom the next season. ‘Emerald’ plants fertilized with 336 N bloomed one, two, or three weeks earlier than those fertilized with 168 N, 84 N, or 42 N, respectively. There was no difference in time of bloom between the 0 N and 42 N treatments. Similarly, bloom on ‘Farthing’ plants fertilized with 336 N or 168 N was advanced by one week compared with the other treatments.

Specified Source(s) of Funding: National Science Foundation

Oral Presentations

Optimization of Growth-stage Specific Nitrogen Fertilization Improves Strawberry Growth and Yield
Shinsuke Agehara
Gulf Coast REC, University of Florida, Wimauma, FL
Bhagatveer Sangha*
Gulf Coast REC, University of Florida, Wimauma, FL

Nitrogen (N) fertilization rate is generally based on growth stage to ensure optimal N fertilization in strawberry. The objective of this study was to determine optimal growth-stage specific N fertilization rates for ‘Florida Radiance’ and ‘Florida 127’ strawberry cultivars. Field experiments were conducted during 2014–15 and 2015–16 growing seasons using standard production practices in Florida. In the first season, five N rates of 0.2, 0.6, 1.0, 1.4 and 1.8 lb/acre/d were evaluated from the establishment to early harvest (Oct- Dec). In the second season, four N rates of 0.75, 1.0, 1.5 and 2.0 lb/acre/d were evaluated during the establishment (3 weeks), early harvest (Nov-Dec), and late harvest (Jan-Mar). All treatments received the same N rate of 1.0 lb/acre/d except the treatment periods described. In the first season, canopy width and crown diameter in Dec. maximized at 1.0 and 1.8 lb/acre/d for ‘Florida Radiance’ and ‘Florida 127’, respectively. This enhanced vegetative growth increased marketable yield not only during the early harvest but also during the late harvest. The highest marketable yield was recorded at 1.8 lb/acre/d for ‘Florida Radiance’ and 1.4 lb/acre/d for ‘Florida 127’. Similarly, the second season’s maximum marketable yield for ‘Florida Radiance’ and ‘Florida 127’ was recorded at 1.5 and 1.0 lb N/acre/d applied from the establishment to early harvest. Both cultivars maximized marketable yield when fertilized within a range of 0.75–1.0 lb/acre/d during the late harvest. The application of N at rates 1.5 lb/acre/d or higher during the late harvest increased unmarketable yield by 41% to 42% in both cultivars, limiting the increase in marketable yield by N fertilization. Although sap nitrate concentration in the late season treatments increased from 705 to 1450 ppm in ‘Florida Radiance’ and from 340 to 1233 ppm in ‘Florida 127’ with increasing N from 0.75 to 2.0 lb/acre/d, there was no correlation between sap nitrate concentration and marketable yield (r² = 0.008). These results suggest that marketable yield of strawberry is most responsive to N fertilization from the establishment to early harvest. Thereafter, N fertilization should be maintained relatively lower to improve the percentage of marketable yield and fertilizer use efficiency.

Specified Source(s) of Funding: Florida Strawberry Grower Association

An asterisk (*) following a name indicates the presenting author.
Effects of Phosphorus Rates on Phosphorus Uptake and Yield of Tomato Grown on a Calcareous Soil
Qiang Zhu*
University of Florida, Immokalee, FL
Monica Ozores-Hampton
University of Florida, Immokalee, FL
Yuncong Li
University of Florida, Homestead, FL
Kelly Morgan
University of Florida, Immokalee, FL

Developing a fast and reliable soil testing method is important for improving soil test efficiency and ensuring reliable fertilizer recommendation. Currently, no official extractant for calcareous soils exists for vegetable growers in Florida. There are, accordingly, no phosphorous (P) fertilizer recommendations available for vegetable production on such soil. The objective of this experiment was to evaluate the effects of different P rates on P uptake, yield, and postharvest quality of tomato (Solanum lycopersicum) grown on a calcareous soil. Six rates of P (0, 29, 49, 78, 98, and 118 kg·ha⁻¹) were applied as pre-plant dry fertilizers. Tomatoes were grown using plasticulture system with drip irrigation during the winter growing season of 2014. Results showed that P rates greater than 29 kg·ha⁻¹ produced optimal tissue P content at the early fruit set stage; however, the P tissue contents in all P rates were lower than the optimal range before the first harvest. At 60 days after transplanting (DAT), the total plant biomass and P uptake by leaf, stem, root, and fruit were estimated by linear-plateau model with critical rate at 98 kg·ha⁻¹ of P. At 97 DAT, linear response of P uptake by plant was obtained meaning that as P rates increased the uptake increased. There were no significant differences in P uptake at 30 and 135 DAT. The linear regression model was validated to predict the first harvested total marketable yield, which indicated that fruit yield increased with P application rates increased. The total season marketable yield, ranged from 75.8 to 86.4 t·ha⁻¹ among the six P rates, and the tomato postharvest qualities were not significantly affected by P rates. Therefore, based on this experiment with 11.3 mg·kg⁻¹ ammonium bicarbonate-DTPA (AB-DTPA) extractable P, the P application rate of 118 kg·ha⁻¹ should be recommended to tomato growers for the winter growing season on a calcareous soil in Florida.

The Effects of Foliar Nutrient Applications on Fruit Split, Quality, and Yield and Leaf Nutrient Concentration of ‘Wonderful’ Pomegranate (Punica granatum L.)
John M. Chater*
University of California, Riverside, Riverside, CA
Lauren Garner
California Polytechnic State University San Luis Obispo, California, San Luis Obispo, CA

Foliar nutrient applications have been used experimentally to mitigate pomegranate fruit split but none have been conducted using the industry standard cultivar, Wonderful, and little is known about the effects of foliar nutrient applications on pomegranate. ‘Wonderful’ pomegranate trees at 2 commercial orchards were treated with foliar applications of ZnSO₄ (3000 mg·L⁻¹, 4000 mg·L⁻¹, or 5000 mg·L⁻¹), MgSO₄ (1%, 2%, or 3%), KNO₃ (1%, 2%, or 3%), or deionized (DI) water (control). Fruit were analyzed for fruit split incidence, yield, total soluble solids (TSS), titratable acidity (TA), and mineral nutrient concentrations of leaves and fruit. Foliar applications of MgSO₄ and ZnSO₄ resulted in significantly lower fruit split incidence. Treatments had no significant effect on yield. Leaf N, K, S, Mn, and Zn were significantly affected by the treatments. The TSS and TA were not affected significantly by treatments. Zinc-treated trees had greater fruit Zn concentrations. The results suggest that foliar ZnSO₄ or MgSO₄ could be used to decrease fruit split incidence and increase nutritional content of ‘Wonderful’ pomegranate and any of the three tested foliar nutrients could be applied as a foliar fertilizer without negatively impacting fruit yield, internal quality, or mineral nutrient concentration.

Fertilization Is One of the Most Economical and Environmentally-friendly Management Tools in Container Nursery Crop Production
Youbin Zheng*
Vineland Research and Innovation Centre, Vineland Station, ON, Canada
Mary Jane Clark
Vineland Research and Innovation Centre, Vineland Station, ON, Canada

Excess fertilization is not only costly, but can also injure plants and cause unnecessary nutrient runoff, resulting in environmental damage. However, insufficient fertilization can result in plants showing symptoms of nutrient deficiencies, reduce crop productivity, and eventually reduce the efficiency of other resource inputs during nursery crop production. When optimal fertilizer application rates are used, nursery crops will perform at their best, and growers will be able to maximize resource-use efficiency, which can improve profit margins while minimizing negative environmental impacts. To provide optimal fertilization rate recommendations for container-grown nursery crops in temperate climate regions, we conducted extensive on-farm trials between 2012 and 2016. The trials were conducted at five commercial nurseries and two research campuses, located in different regions within Ontario, Canada. More than ten fertilizer types, two application methods (i.e., incorporation and topdressing), and more than 25 crop species were tested during production in one-, two- and five-gallon containers. This talk...
will present optimal fertilization rates for multiple container nursery crops, as well as crop performance (e.g., growth), nutrient leaching and water use in response to different fertilization practices (e.g., application methods and timing). The results clearly demonstrated that fertilization was one of the most economical and environmentally-friendly management tools in container nursery crop production. For example, when the fertilizer application method, rate and timing are correct, it can significantly save water and other resources.

Specified Source(s) of Funding: This work was financially supported by Agriculture and Agri-Food Canada through the Canadian Agricultural Adaptation Program (CAAP), Ornamental Horticulture Cluster Research Program, Canadian Ornamental Horticulture Alliance, Landscape Ontario, and Agrium Advanced Technologies. Thanks to our nursery partners and horticultural suppliers for providing materials, time, and expertise.

3:15–3:30 PM

Changes in Nitrate Contents of Hydroponically Grown Leaf Lettuce As Influenced by the Ratio of Ammonium and Nitrate Forms of Nitrogen in Nutrient Solution

Changhyeon Kim
North Dakota State University, Fargo, ND

Larry J. Cihacek
North Dakota State University, Fargo, ND

Chiwon Lee*
North Dakota State University, Fargo, ND

Increased levels of nitrate (NO₃⁻) in leafy vegetables may be considered hazardous to human health. An experiment was conducted to determine if changes in the ratio of the two different forms (NH₄⁺,NO₃⁻) of nitrogen (N) can influence tissue nitrate content. Rockwool-grown seedlings of leaf lettuce (Lactuca sativa) cv. Rex Rz were anchored and grown on Styrofoam boards inside tubs containing 5 different N solutions: 1) 100% NH₄⁺; 2) 75% NH₄⁺,+25% NO₃⁻; 3) 50% NH₄⁺+50% NO₃⁻; 4) 25% NH₄⁺,+75% NO₃⁻; and 5) 100% NO₃⁻ at total 12 of meq/L N. All fertilizer solutions contained modified levels of other macronutrients from a Hoagland solution. When lettuce plants were harvested after 4 weeks of culture, tissue nitrate levels were higher when the nutrient solution contained increasing percentage of NO₃⁻ in relation to NH₄⁺ in general. The growth of the plants was the greatest when it was grown with 1:1 mixture of NH₄⁺ and NO₃⁻ (solution 3). Tissue nitrate content in this treatment was about 4000 ppm higher compared to solution 2. Difference in biomass yield between the solution 3 and solution 2 was statistically not significant. As tissue NO₃⁻ levels increased, plant sap pH values increased and the leaf chlorophyll index became lower. It appears that a hydroponic solution containing 75% NH₄⁺,+25% NO₃⁻ can effectively be used for growing lettuce to lower leaf nitrate levels without sacrificing yield and produce quality.

Specified Source(s) of Funding: NDDA-SCBG

Oral Session—Fruit Breeding 1

Moderator: Ksenija Gasic
Clemson University, Clemson, SC

2:00–2:15 PM

Evaluation of Field Book: An Open-source Android App for Collecting Phenotypic Data in a Peach Breeding Program

Ksenija Gasic*
Clemson University, Clemson, SC

Trevor Rife
Kansas State University, Manhattan, KS

Jesse A. Poland
Kansas State University, Manhattan, KS

Sook Jung
Washington State University, Pullman, WA

Kate M. Evans
Washington State University, TFREC, Wenatchee, WA

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Concomitant advances in high-throughput sequencing, phenotyping, and computational technologies, are generating petabytes of genomic, genetic, and breeding data for Rosaceae crops. Efficient utilization of this data by the research community requires analysis, integration, and visualization. The Genome Database for Rosaceae (GDR) is working toward enabling high-resolution dissection of traits and relating molecular diversity to functional variation for efficient development of new cultivars through marker-assisted breeding. Plant breeding programs generate and search through thousands of plants to find the best plant types, which will become new improved cultivars. A typical breeding program produces hundreds of thousands of phenotypic data points in a given year. Inefficient and poor handling of this data decreases the genetic gain of the breeding program, consequently reducing its efficiency. While data handling has been a limiting area for breeding programs in the past, advances in computing have provided simple solutions that can address the needs of plant breeding programs. Using open-source software and relatively inexpensive phone and tablet hardware, GDR is supporting development of a platform that will allow researchers to replace hard-copy field books, thus alleviating the possibility of transcription errors while providing faster access to the collected data. The peach breeding program at Clemson University is testing the Field Book app for collecting data on

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

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High density, Multi-population Consensus Genetic Linkage Map for Peach (Prunus persica L. Batsch)

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Highly saturated genetic linkage maps are extremely helpful to breeders and are essential prerequisite for a number of biological applications, such as the identification of marker-trait associations, mapping quantitative trait loci (QTL), candidate gene identification, the development of molecular markers for marker-assisted selection (MAS), and association and comparative genetic studies. Several high density inter- and inraspecific genetic maps, constructed using 9K SNP peach array, are available for peach. However, these genetic maps are based on single mapping population and have limited use for QTL discovery and comparative studies. A consensus genetic linkage map developed from multiple different populations provide not only a higher marker density and a greater genome coverage when compared to the individual maps, but also serve as valuable tools for estimating genetic positions of unmapped markers. In this study, four high density inraspecific Prunus persica genetic maps, ‘O’Henry’ x ‘Clayton’ (OC), PJ91459 (‘NJ Weeping’) x ‘Bounty’ (WB), ‘Venus’ x ‘Venus’ (VV), and updated ‘Zin Dai’ x ‘Crimson Lady’ (ZC), and interspecific ‘Texas’ x ‘Earlygold’ (T x E) map were used for the development of a consensus genetic linkage map for peach. The consensus linkage map contains a total of 4015 molecular markers, consisting of 9 SSRs, 4005 SNPs and 1 morphological marker associated with slow ripening in peach. The map spans a genetic distance of 844.8 cM with an average marker density of 0.7 cM/marker. This consensus genetic linkage map represents the most comprehensive peach map available to date and will serve as a new reference map for the Prunus genus. It will support QTL identification and molecular marker development for peach and other genetic studies within the Rosaceae.

Specified Source(s) of Funding: USDA-NIFA 2009-51181-05808 & 2014-51181-22378

2:15–2:30 PM

Introgressing Multiple Disease Resistance Alleles into Elite Apple Cultivars By DNA-informed Breeding

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Plant diseases cause substantial economic losses for the world wide apple industry. For example, powdery mildew is prevalent and damaging in the major U.S. production regions and blue mold is destructive during fruit storage. Chemical controls are costly and potentially damaging to the environment and human health. Planting disease resistant cultivars is a promising way to mitigate plant diseases. However, single sources of genetic resistance might limit the choice of commercial cultivation conditions. Cultivars with multiple disease resistance could be grown in diverse growing region of the world. Although many disease resistant apple cultivars have been released, none are widely planted due to less-than-ideal genetic potential for fruit quality. Introgressing multiple disease resistance alleles into single elite cultivars is time-consuming and inefficient owing to the extended juvenility of the crop and the need to purge undefined poor fruit-quality alleles over multiple generations, and the difficult evaluation of multiple disease susceptibilities phenotypically. DNA-informed breeding employed by collaborating breeders in the RosBREED project could make this introgression more efficient. The objective of this study is to enable breeders to select cultivars with durable disease resistance and superior fruit quality by 1) developing DNA tests for powdery mildew and blue mold resistance and 2) developing DNA-informed introgression strategies for multiple resistances and demonstrating them in the Washington State University Apple Breeding Program. Targeting previously discovered breeding-relevant trait loci, trait-predictive DNA tests to detect Pl-w (from the cultivated crab apple ‘White Angel’, with wild species ancestry of Malus sargentii and M. sieboldii) and Pe3 (from wild species M. sieversii P1613981) resistance alleles were developed. Two segregating populations consisting of 100 and 230 individuals from ‘Sunrise Magic’ x ‘White Angel’ and ‘Royal Gala’ x P1613981, respectively, were utilized to establish associations between DNA markers and disease susceptibility.
DNA test Plw-SSR targeting Pl-w locus could accurately detect offspring with powdery mildew resistance. DNA test Pcs-SSR can identify seedlings with about 60% smaller lesion diameter compared to the susceptible sibling seedlings. Concurrently, introgression strategies, e.g., marker-assisted foreground selection for known fruit quality and disease resistance alleles and marker-assisted background selection against presumably undesirable wild alleles from donor parents, are under investigation. Further alleles conferring powdery mildew resistance from other sources, e.g., M. robusta and M. zumi, could be incorporated into elite cultivars through the application of introgression strategies developed in this project.

Specified Source(s) of Funding: USDA-RosBREED

2:45–3:00 PM

Major Locus for Tolerance to Botryosphaeria dothidea in Prunus

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Botryosphaeria spp. is a fungal pathogen complex associated with wood infections in multiple perennial plant species worldwide. Isolates from peach orchards in eight different locations across Florida and Georgia were examined using morphological characteristics and nucleotide sequences of the internal transcribed spacer region (ITS). A preliminary survey identified Botryosphaeria dothidea (anamorph Fusarium aesculi), B. rhodina (anamorph Lasiodiplodia theobromae), and B. obtusa (anamorph Diplodia seriata) associated with wood canker in the genus Prunus in the Southeastern United States. All species were found to be pathogenic, when they were artificially inoculated on one-year-old peach seedlings. A survey of subtropical peach germplasm at the University of Florida did not detect significant levels of tolerance to Botryosphaeria canker. However, examination of interspecific crosses using P. dulcis (Mill.) D.A. Webb, and P. kansuensis Rehder detected a potential source of tolerance for B. dothidea pathogen in the almond cultivar ‘Tardy Nonpareil’ (TNP). Pathogenicity tests using conidial suspensions on wounded peach, and peach x almond seedlings confirmed the virulence of B. dothidea strains. A total of 865 F₁ and backcross progeny, generated by open pollinating and backcrossing tolerant peach x almond F₁s to peach, were evaluated for tolerance to Botryosphaeria disease using 3 different techniques: natural infection; infection trellis system for enhanced inoculation, and mycelial slurries of B. dothidea on wounded plants. The results from the three different screening techniques were highly correlated. Linkage analysis identified a region associated with disease tolerance in chimeric chromo-
some 6–8 in the UFSharp x (Flordaguard x TNP) backcross population. The red leaf phenotype in peach co-segregates with a reciprocal translocation between chromosomes 6 and 8. The Botryosphaeria tolerance locus maps to this chimeric chromosome. Clonal replicates of the backcross population, evaluated on susceptible ‘Flordaguard’ rootstocks at Byron, GA, indicated that susceptibility and tolerance of the scion are independent from rootstock susceptibility. Additionally, tree diameter or vigor was not correlated with disease tolerance. The F₂ and BC₁ populations confirmed the presence of a single dominant locus associated with tolerance. Mapping of additional SSR markers for tolerance to B. dothidea, and introgression of the tolerance region into commercial quality germplasm is ongoing.

Specified Source(s) of Funding: UF Stonefruit breeding program

Oral Session—Marketing and Economics

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

3:30–3:45 PM

Does Consumer Awareness of Neonicotinoid Insecticides Influence Their Preferences for Plants?

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Consumer awareness of neonicotinoid (neonic) insecticides is growing (in part) due to increased publicity and media attention. Environmental groups want neonic insecticides to be banned because of their perceived potential negative consequences on non-target species (especially bees and other pollinator insects). Several retail outlets and governmental agencies are now requiring the ornamental horticulture industry (hereafter, green industry) to label plants grown using neonic insecticides. While the scientific value of the mandatory labeling policies is debatable, neonic labeling may negatively influence consumers’ demand for plants. Research on consumers’ awareness of neonic insecticides is limited, and the extent to which awareness influences preferences and shopping behavior is less understood. This manuscript addresses these research gaps by investigating correlations between awareness of neonic insecticides, knowledge about related topics (e.g., gardening, pollinator insect health), and purchase likelihood, using an online survey of 921 U.S. consumers. Results indicate that only 24% of surveyed plant purchasers are aware of neonic insecticides. Consumers who are aware of neonic insecticides are more knowledgeable about plants that improve pollinator health and entomology than those who are not aware. Labels with “neonic-free” wording were the least preferred and influential pollinator related in-store promotion. However, awareness of neonic insecticides was
positively correlated with consumers’ purchase likelihood for “neonic-free” plants. Overall, awareness influences consumers’ shopping behavior which could necessitate altering green industry pest management strategies as consumers’ awareness of neonic insecticides increases due to the negative publicity surrounding it.

Specified Source(s) of Funding: UF-MREC

3:45–4:00 PM

Seed Your Future: A National Initiative to Promote Horticulture

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Marnie Conley
Longwood Gardens, Kennett Square, PA

Seed Your Future began in 2013 as an initiative to promote horticulture with Longwood Gardens and ASHS. Additional collaborators include the American Public Gardens Association, National Junior Horticultural Association, AmericanHort, and the American Horticultural Society. FleishmanHillard (FH, Washington, DC), a nationally recognized communications and marketing firm, was engaged to conduct research with internal and external audiences to determine the public perception of horticulture and careers in horticulture. Through stakeholder focus groups and general public online and phone surveys, the importance of horticulture, career perceptions and the need for the promotion of horticulture were examined. Students, faculty, industry and administrators in horticulture have a broad understanding of the field, much more than the public, especially young, ethnically diverse, and lower income participants. While lack of public awareness is one of the biggest challenges in horticulture, it is also its greatest opportunity. Sixty-five percent of all phone survey participants as compared to 41% of 18–24 years old revealed a general awareness of the word horticulture. General public found agreement (48% to 59%) with four statements about the essential, universal and invaluable worth of horticulture; however, strong agreement was less, ranging from 26% to 46%. Only 26% of respondents felt strong agreement with the statement, “Horticulture is a diverse area of study, and it offers viable, fulfilling and respected career paths that I would recommend to others”. The research found strong stakeholder support for a national promotion of horticulture. A strategic plan has been formulated along with a new careers video and website: seedyourfuture.org. Leadership has expanded to include an Advisory Council co-chaired by Charlie Hall, Texas A&M and Janet Mahoney, Director Global Total Rewards, Discoll’s; and a National Leadership Cabinet co-chaired by Anna Ball, President, Ball Horticultural Co., and Paul Redman, Director, Longwood Gardens. A timeline and further updates will be presented on the initiative.

4:00–4:15 PM

Benchmarking the Efficiency of Transplanting Plant Cuttings

Yai Ulrich Adegbola*
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Paul Fisher
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Transplant of unrooted cuttings is an important process in the production of rooted liner trays. There is potential for companies producing young plants to decrease production cost and increase profit margin by improving the efficiency of this process. However, there has been no comprehensive analysis regarding cutting transplant efficiency. This study focused on 1) benchmarking labor productivity with transplanting cuttings at young plant operations, and 2) identifying key factors that differentiate efficiency between businesses and workers. We collected data on the transplanting process of 14 greenhouse companies during the peak spring season. For example, in one greenhouse (A), the total labor cost was $44,033 with 110 employees receiving, transplanting and handling 2,974,713 cuttings during one week in the peak period, and the labor cost per cutting was $0.0148. In contrast, the total labor cost in another greenhouse (B) was $15,816 with 172 employees processing 1,600,000 cuttings, and the labor cost per cutting was $0.0099 [33% lower than (A)]. This illustrates a wide variation of labor cost and productivity between greenhouses and potential for improved efficiency. For the entire process in greenhouse (A), receiving and handling imported cuttings represented 10% of total labor cost, filling trays with root substrate was 6%, supervision was 7%, transplanting cuttings into trays was 67%, and moving cuttings to the greenhouse bench was 10%. These figures can be used to evaluate return on investment of robotics for the transplant process, benchmarking rooted liner production within and between companies, and allow us to calculate enterprise budgets. Results are expected to assist growers in decreasing production cost and increasing profit margin. Transplant of unrooted cuttings is an important process in the production of rooted liner trays. There is potential for companies producing young plants to decrease production cost and increase profit margin by improving the efficiency of this process. However, there has been no comprehensive analysis regarding cutting transplant efficiency. This study focused on 1) benchmarking labor productivity with transplanting cuttings at young plant operations, and 2) identifying key factors that differentiate efficiency between businesses and workers. We collected data on the transplanting process of 11 greenhouse companies during the peak spring season. For example, in one greenhouse (A), the total labor cost was $44,033 with 110 employees receiving,
transplanting and handling 2,900,000 cuttings during one week in the peak period, and the labor cost per cutting was $0.0152. In contrast, the total labor cost in another greenhouse (B) was $15,816 with 172 employees processing 1,600,000 cuttings, and the labor cost per cutting was $0.0099 [35% lower than (A)]. This illustrates a wide variation of labor cost and productivity between greenhouses and potential for improved efficiency. For the entire process in greenhouse (A), receiving and handling imported cuttings represented 10% of total labor cost, filling trays with root substrate was 6%, supervision was 7%, transplanting cuttings into trays was 67%, and moving cuttings to the greenhouse bench was 10%. These figures can be used to evaluate return on investment of robotics for the transplant process, benchmarking rooted liner production within and between companies, and allow us to calculate enterprise budgets. Results are expected to assist growers in decreasing production cost and increasing profit margin.

4:15–4:30 PM

The Social Responsibility Journey of the Canadian’s Peat Moss Industry

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Stephanie Boudreau
CSPMA/APTHQ, Rivière-du-Loup, QC, Canada

Social and environmental concerns have become increasingly influential in consumers’ purchasing decisions and critical to ensure companies’ and industries’ social license to operate. This increased awareness may quickly destroy the reputation of any business perceived to be behaving unethically—but also entails an opportunity to engage in positive change and enhance stakeholder understanding and collaboration to ensure lasting economic growth. And this is what achieved the Association des producteurs de tourbe horticole du Québec (APTHQ) and the Canadian Sphagnum Peat Moss Association (CSPMA) by developing their first industry social responsibility (ISR) report. This communication is about the associations’ social responsibility journey leading to this publication and its outcomes for the industry. Specifically, it relates how the APTHQ and the CSPMA transformed environmental challenges into market opportunities while creating a culture of continuous improvement by doing and saying the right things. Developed as part of the Sustainability Assessment of Food and Agriculture Systems (SAFA) pilot project of the Food and Agriculture Organization (FAO), this report capitalized on the past achievements of the associations in the field of sustainability to provide the industry with a benchmark for sustainable accounting on its governance, social, environmental and economic impacts. In particular, the associations used the SAFA guidelines to structure and organize in a coherent and systematic way the results from existing initiatives or reports, such as the social and environmental life cycle assessments (LCA), certification standards (Veriflora®) and the annual reports. In order to identify and prioritize peat moss sustainable issues and define objectives to meet them, a stakeholder consultation involving consumers, environmentalist groups, local community organization representatives, peat moss producers, and representatives from the industry’s associations was also conducted. In the end, the report was third party reviewed to reinforce its credibility. This first report, published in 2014, facilitated communication to various stakeholders on the sector’s sustainability efforts as well as the sector’s upcoming commitments to be undertaken in preparation to the next publication in 2017. The associations already undertook in 2016 to update the industry’s social, economic, environmental, and governance profile by conducting a survey among their members. This new information will be used by the associations and their members to compare their performance, identify new areas for improvements, and engage in constructive dialogue with their stakeholders in order to remain a sustainable practices leader in the production of sphagnum peat moss products and a model for its social responsibility practices.
A Twitter account was launched on 25 Feb. 2016 and as of 30 Mar. 2016 it had 137 followers and was viewed over 12,300 times. Social media applications were used for the promotion of Florida Hops and reviewed in this case study to open discussion of the challenges and opportunities social media presents for horticulture.

4:45–5:00 PM

Virginians Perceptions of Fresh Produce Food Safety

Bridget Behe*
Michigan State University, East Lansing, MI

Amber Vallotton
Virginia Polytechnic Institute & State University, Blacksburg

Joyce Latimer
Virginia Polytechnic Institute & State University, Blacksburg, VA

The Food Safety Modernization Act signed into law in 2011 established some minimum standards based on known safety risks for produce growers to implement and document. However, an estimated 48 million foodborne illnesses are reported each year in the United States with approximately 3000 deaths resulting. Our objective was to understand just how safe consumers perceive their produce is. We developed a 54 item online survey that was administered with Qualtrics (Provo, UT) online platform. A sample of 636 participants from Virginia was recruited from GMI Lightspeed (Warren, NJ), which maintains a panel of 5.5 million individuals. Responses were collected from 15 to 22 Sept. 2015. The sample of 636 respondents was comprised of 70.1% females and 24.6% males (5.3% did not respond). Mean age was 50 years and households had a mean 2.3 adults and 1.8 children. Only 20.3% had a high school education or less and 34.0% lived in a suburban region. Mean household income was $65,615. Of the total responses, 67.4% agreed or strongly agreed that “I don’t have time to worry about food safety” and 17% agreed or strongly agreed that “Consumers assume the produce they buy is safe to eat.” However, 81% agreed or strongly agreed that “I am confident that the produce I buy is safe to eat” and 63.7% agreed or strongly agreed that “I rely on the farmer to make sure my food is safe.” The analysis of the conjoint portion of the study revealed that the purchase source (farmer’s market, natural food store/cooperative, roadside stand, or supermarket) was relatively the most important of the three attributes to determining food safety, accounting for nearly 43% of the rating for safe food, followed closely by the produce itself (40%). Production method accounted for only 17% of the decision on how safe the food was. The safest produce was the grape tomato, followed by the mixed berries, and leafy greens. Sprouts were perceived to be the most risky (lowest utility estimate). Among the four options for purchase source, the perceived safest place was a natural food store or cooperative. The supermarket and farmers market were similar and slightly safer purchase locations and compared to the roadside stand, which was perceived to be the least safe place among the four listed to purchase produce.

5:00–5:15 PM

The Role of Trust: How Consumers Value Information from Different Retail Outlets

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Julie Campbell
University of Connecticut, Storrs, CT

Victoria Wallace
University of Connecticut, Storrs, CT

Trust is a critical issue for many green industry firms. Anecdotal evidence suggests that consumers view retailers (e.g., independent garden centers vs. box stores and independent lawn service providers vs. large lawn care providers) differently when it comes to perceptions of quality, price, and value of information provided. For instance, a common perception is that prices are higher at independent garden centers compared to box stores, while quality is higher at independent garden centers compared to box stores. In this study we compare consumer perception of price and quality at independent garden centers and box stores as well as independent lawn care services versus large lawn care service providers. Furthermore, we evaluate how consumers value product (such as organic, sustainable, etc.) information and business (pay for workers, knowledge of products, water/energy conserving practices, customer service, etc.) practices across retail outlets. Results on the online study provide interesting insights into the differences associated with perceived large business versus more “local” firms. Furthermore, demographics play a role in both shopping at and perceptions associated with these store types. Firm level recommendations are provided so that the various types of firms can better understand consumer perceived strengths and weaknesses.

Oral Session—Organic Horticulture 2

Moderator: Xin Zhao
University of Florida, Gainesville, FL

4:00–4:15 PM

The Influence of High-tunnel Production on Yield and Fruit Quality of Organically Grown Tomato

Xin Zhao*
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Zack Black
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An asterisk (*) following a name indicates the presenting author.
Results of a Two-year Study into the Effect of Winter Cover Crops on Production of High-tunnel Vegetable Crops

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University of Arkansas, Fayetteville, AR
Curt Rom
University of Arkansas, Fayetteville, AR

This two-year study investigated short-season winter cover crops to improve soil quality and reduce nitrogen fertilizer inputs in organic high tunnel production systems. Five winter cover crop treatments were investigated including a nontreated control, Austrian winter peas (Pisum arvense), bell beans (Vicia faba), mustard (Brassica juncea cv. Kodiak), and Daikon radish (Raphanus sativus var. longipinnatus). Cover crops were grown in a high tunnel from mid-Nov to mid-April in a randomized complete block design with three replications. After incorporation, the cover crops were followed by a succession of vegetable crops, including tomato (Lycopersicon lycopersicum, cv. ‘Plum Dandy’) and broccoli (Brassica oleracea var. italica, cv. ‘Bay Meadows’). Crops were fertilized at a 0.5x rate (56 kg·ha⁻¹ N) with the objective to determine the ability of the cover crop treatments to supplement fertilizer inputs. Yield and performance of the vegetable crops were measured to determine the effects of the cover crop treatments compared to a nontreated control. In both years of the study Austrian winter peas yielded significantly greater cover crop biomass and contributed a greater amount of biomass nitrogen than all other treatments. This led to a significantly lower soil C:N ratio 30 days after incorporation. Tomato leaf chlorophyll measurements were highest following winter pea with significant differences detected in 2015. Though statistical differences were not detected due to plot variation caused by environmental factors, the winter pea cover crop resulted in a 48% increase in mean tomato yield compared to the control. Broccoli early-season leaf chlorophyll was also increased by the winter pea treatment and plant biomass was significantly greater, but harvest data were not significantly different.

Specified Source(s) of Funding: Southern SARE

4:30–4:45 PM


Julie Laudick*
The Ohio State University-OARDC, Wooster, OH
Brian Gardener
Sustane Natural Fertilizer, Cannon Falls, MN
Matthew Kleinhenz
The Ohio State University-OARDC, Wooster, OH

Growers increasingly seek biological alternatives to chemical inputs in the form of microbe-containing bioproducts (e.g., biofertilizers, biostimulants, biopesticides) (MCBPs) applied to seeds, plants, roots, or soils to promote growth, or limit disease or abiotic stress. Trends in MCBP use were tracked from 2009–14 by surveying the organic certification records of 86 Ohio organic vegetable farmers. A total of 22 biofertilizer products from 12 different manufacturers, and 10 biopesticide products from eight manufacturers were reportedly used over the 6-year period. Biopesticides were used by 65% of farmers and accounted for 4.3% of all inputs by number. Similarly, biofertilizers were used by 51% of farmers and accounted for 4.8% of all inputs by number. Biopesticides were grouped into three categories: BT (Bacillus thuringiensis), other insecticides, and fungal antagonists, which accounted for 65%, 13%, and 21% of all uses, respectively. All biopesticide products contained a single species as the active ingredient, which was identified at the strain level.
in every case. In contrast, the most widely used biofertilizers were products containing mixtures of different bacterial and/or fungal species. These mixed products accounted for 40% of all biofertilizer use, and products containing unspecified “beneficial microorganisms” accounted for 28% of all biofertilizer use. Rhizobia and mycorrhizal fungi accounted for 21% and 10% of use, respectively, and symbiotic nitrogen fixing inoculants accounted for the remaining 2%. These patterns of MCBP use are consistent with what is available commercially. A potential biopesticide strain must go through extensive testing in order to be registered by the EPA, whereas there are virtually no regulations for biofertilizers. The vast majority of commercially available biofertilizers are mixed inoculants, and many products have imprecisely labeled ingredients and unclear application instructions. Furthermore, little independent, research-based, and publically available information is available to substantiate claims of product efficacy. That so many farmers use biofertilizers despite the present lack of reliable information about them suggests a need for more research and extension.

4:45–5:00 PM

**High Tunnel Pest Exclusion (HTPE) System Using Shade Cloth for Reducing Leaffooted Bugs and Caterpillars from Vegetable Crops**

Ayanava Majumdar*
Alabama Cooperative Extn System, Auburn, AL

James Miles
Alabama Cooperative Extension System, Mobile, AL

William East
Alabama Cooperative Extension System, Ashland, AL

Organic vegetable production is increasing in the South with many beginning and experienced farmers growing crops in the high tunnels. Although high tunnels are useful for season extension, they also extend the life cycle of insect pests that complete generations rapidly inside the protected structures. In Alabama, organic vegetable production is severely challenged by insect pests that can cause 30% to 50% direct crop loss or contamination of produce if uncontrolled. Therefore, in organic farming, pest prevention is certainly better than cure. This paper describes a pest exclusion system suitable for high tunnel producers. The authors evaluated 0 (check), 30%, 40%, and 50% knitted shade cloth in the laboratory for their potential to stop large insect pests of tomatoes using high tunnel pest exclusion models. Six types of shade cloth were installed on the side- and end-walls to get optimum pest exclusion. We focused on leaffooted bugs (*Leptoglossus* spp.) and moths since they are universal problems for producers. A 40% or 50% knitted shade cloth from Poly-Tex (MN) and Green-Tek (WI) significantly reduced leaffooted bug numbers and protected vegetables placed inside the model. Large moths were not able to penetrate the fabric. This paper will end with a discussion of on-farm successes with the HTPE system.

**Specified Source(s) of Funding:** SARE Professional Development Grants (2014 and 2015)

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An asterisk (*) following a name indicates the presenting author.
Based on these results, we have identified productive and high quality varieties and breeding lines for further selection in the upper Midwest.

Specified Source(s) of Funding: North Central Sustainable Agriculture Research and Education Program USDA

Oral Session—Growth Chambers and Controlled Environments 3
Moderator: Hye-Ji Kim
Purdue University, West Lafayette, IN

4:00–4:15 PM

Growth Promotion by a Microbial Biostimulant Depends on Application Frequency in Semi-protected Fall-to-Spring Lettuce Production in Ohio
Zheng Wang*
The Ohio State University-OARDC, Wooster, OH
Julie Laudick
The Ohio State University-OARDC, Wooster, OH
Matthew Kleinhenz
The Ohio State University-OARDC, Wooster, OH

Microbial biostimulants (MBSs) contain one or more types of selected bacteria or fungi and other components and they are applied to enhance crop growth and/or tolerance of abiotic stress. Two sets of experience spur interest in MBSs among researchers, growers, and industry: 1) numerous scientific experiments demonstrating that pure cultures of individual strains can alter plant vegetative and fruiting parameters in controlled settings, and 2) MBS manufacturer and grower claims that MBSs can enhance farm productivity. Experience also indicates that MBS performance is context-dependent and that conditions under which they perform most consistently are not well understood. MBS effects under dynamic temperature, moisture, and other conditions common to fall- and springtime leafy vegetable production in semi-controlled settings in Ohio appear to be untested. The longevity of inoculant-derived microbes under these conditions and hence, optimal MBS application frequency, is also unclear. Therefore, we set out to determine whether fall-time MBS application enhances lettuce productivity fall and spring, whether these effects depend on application frequency, and whether soil microbial populations in inoculated and control plots differ long after treatment. A randomized complete block design with five replications was used. Organic 'Parris Island' lettuce seeds were sown on 5 Nov. 2015 at the OARDC at a rate of 9700 seeds/m² into five, 9.1 m x 1.2 m, wood-framed, un-heated raised beds covered with medium weight (34 g·m⁻²) floating row covers and 6-mil embossed greenhouse film overtop gothic-shaped frames. Certifiable-organic rooting medium in the 30 cm-high beds consisted of 30% peat moss, 20% parboiled rice hulls, 25% field soil, and 25% compost (by volume). “Biogenesis I NP Soil Amendment”, containing 12 common beneficial rhizobacterial species, was applied as a drench up to four times: 1) none (control); 2) at seeding; 3) at seeding and two weeks thereafter; and 4) at seeding and at weeks two and four after seeding. Plants and rooting medium were collected on 16 Dec. 2015, and 25 Jan. 2016, to measure leaf fresh and dry weight and °Brix and to estimate rhizospheric microbial populations. Soil and air temperatures within the tunnels were monitored with ‘HOBO Pro V2 Temp/Ext-temp’ dataloggers. At Harvest 1, leaf fresh and dry weight and estimated microbial populations, but not °Brix, significantly increased with application frequency. At Harvest 2, however, only plots receiving four applications registered significantly greater fresh weight and °Brix values and microbial populations were lower than at Harvest 1. Other parameters were unaffected.

4:14–4:30 PM

Seed Density, Fertilizer Concentration, Temperature, and Substrate Depth Effect on Three Microgreen Species of the Brassicaceae Family
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Cornell University, Ithaca, NY
Neil Mattson
Cornell University, Ithaca, NY

Microgreens are a young, tender and edible crop harvested shortly after emergence of the first true leaf. To date, insufficient published data exists on the influence of cultivation practices on plant yield, morphology, and nutritional composition of microgreens. The objective of this research is to determine the effects of varying seeding densities, fertilizer concentrations, ambient air temperatures, and substrate depths on the growth of microgreens. Four experiments were conducted to independently determine the influence of seeding density (1.1, 1.65, 2.2, 2.75, and 3.3 seeds/cm²), fertilizer rate (0, 50, 100, 150, and 200 ppm N) at each irrigation, aerial temperature (14 °C, 18 °C, 20 °C, and 22 °C) from germination to harvest and substrate depth (1.8, 3.3, 4.3 and 5.8 cm). Trials were conducted using three species, mizuna (Brassica rapa), arugula (Eruca sativa) and mustard ‘Garnet Giant’ (Brassica juncea) in a glass greenhouse in Ithaca, NY, with temperature trials between the months of December and January. Measured parameters included fresh weight (FW), plant height, and dry weight (DW). Results were analyzed using linear and quadratic regression. Each experiment had between 8 and 12 replicates per treatment combination with a total of 3 experimental replications over time. For temperature trials, FW increased linearly for all three species as temperature increased from 14 °C to 20 °C with little to no further FW gain at 22 °C. Seed density trials showed that for all three species, FW increased in a significant quadratic fashion as seed density increased from 1.1 to 3.3 seeds/cm² with diminishing FW above 2.75 seeds/cm². In the analysis of varying substrate depths, arugula FW increased linearly as substrate depth increased from 1.8 to 5.8 cm. Mizuna was best fit by a quadratic regression with FW increasing as substrate depth increased from 1.8 to 5.8 cm. Evaluation of basic cultivation practices on the growth of these emerging crops is an

An asterisk (*) following a name indicates the presenting author.
important first step in the progression of research surrounding their cultivation. Based our findings, good performance of the three species in this trial can be obtained at a seed density of 2.75 seeds/cm², an aerial temperature between 20 °C and 22 °C, and a substrate depth of 5.8 cm. Further research is underway to evaluate the effects of varying daily light integral (DLI) and CO₂ enrichment on the growth and nutritional characteristics of microgreens.

4:30–4:45 PM

The Effects of Early and Late-season Production with Row Cover Usage of Lettuce (Lactuca sativa) in High Tunnels

Krystal Conway*
Kentucky State University, Frankfort, KY

Anthony Silvernail
Kentucky State University, Frankfort, KY

Kirk Pomper
Kentucky State University, Frankfort, KY

High tunnels are used to assist with extending the growing season of various crops, particularly cool season crops. During this extended season, row covers are often used within the high tunnels for additional temperature increase during the cool season to produce better crops and yields. In this experiment, the use of high tunnels and row covers were explored to extend the growing season of two brands of leaf lettuce. Organic Waldmann’s dark green lettuce, Lactuca sativa, was direct-seeded into four randomized 8.5 ft. x 3.6 ft. plots inside four high tunnels for early season planting. After 42-days from initial planting, Organic Black-Seeded Simpson lettuce was direct-seeded into four randomized 8.5 ft x 3.6 ft plots inside the four high tunnels for late season planting. Each of the four high tunnels had a total of eight randomized plots. Row covers were placed over the plots once germination was seen. There were two replicates of each treatment per high tunnel giving a total of eight replicates. Wet vs. dry weights were collected to determine the weight of the actual plant. Another method of quantifying the quality of crops grown is chlorophyll content and the leaf area. Soil will also be analyzed to determine what factor it plays in the successful growth of each plant. We hypothesize that at harvest, there will be a significant difference between the row covered plots vs. the non-row cover plots due to the increase in weather temperatures. It is also hypothesized that the late season harvest will yield fewer crops than the early season crops. The yields of row cover vs. non-row cover lettuce as well as early season production vs. late season production will be discussed.

4:45–5:00 PM

Temperature Drop Improved Responses of Greenhouse Sweet Peppers to Long Photoperiod of Supplemental Lighting

Xiuming Hao*
Agriculture and Agri-Food Canada

Yun Zhang
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Xiaobin Guo
Agriculture and Agri-Food Canada

Celeste Little
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Jingming Zheng
Agriculture and Agri-Food Canada

Shalin Khosla
Ontario Ministry of Agriculture, Food and Rural Affairs

It is well known that long photoperiods of supplemental lighting cause photo-injury such as leaf chlorosis and necrotic spotting in greenhouse sweet peppers. This photo-injury has limited the application of long photoperiod of supplemental lighting and the yield increase by supplemental lighting, in year-round greenhouse sweet pepper production. In our previous study, we have found that dynamic temperature integration (TI) with temperature drop can improve the response of greenhouse tomatoes to long photoperiods of supplemental lighting because it promoted the translocation of photo-assimilates from leaf to fruit. This promotion of photo-assimilate translocation could also have the potential to help sweet pepper plants to reduce photo-injury and improve the response to long photoperiods of supplemental lighting. Therefore, we conducted this study with the aim to investigate the interactions between photoperiods and temperature control strategies for improving the response of sweet peppers to long photoperiods of supplemental lighting. The study was conducted from Oct. 2015 to Feb. 2016 in eight greenhouse compartments, each with a 50-m² growing area. Two photoperiods (17 h = Control and 21 h = Long Photoperiod) and two temperature integration strategies (Control TI = no temperature drop, and Dynamic TI with temperature drop to 15.5 °C for 3 h at the end of photoperiod) were applied in the eight compartments (two complete replications). Dynamic TI with temperature drop had the same 24-h average temperature as Control TI; the low temperature during the drop period was compensated with higher temperature in other periods over a day (24-h period). Dynamic TI with temperature drop significantly reduced photo-injury and increased fruit yield at the long photoperiod (21 h). Therefore, dynamic temperature integration with temperature drop can be used for improving the response of greenhouse sweet peppers to long photoperiods of supplemental lighting in year-round production.

5:00–5:15 PM

Evaluating Water Use and Yield of Greenhouse Tomato as Affected by LED and HPS Supplemental Lighting during Winter Months

Hye-Ji Kim*
Purdue University, West Lafayette, IN

Cary Mitchell
Purdue University, West Lafayette, IN

Many growers employ hydroponics for growing high value
crops, where plants are cultivated in a soilless substrate with the vast majority of nutritional requirements supplied via the irrigation water. The traditional concepts of surplus irrigation and fertilization conflict with the environmental aspect as it can lead to over irrigation and ground water pollution. In the current study, supplemental lighting was used for commercial high wire tomato production during winter months and the plants were fertigated based on commercial practices with 30% leaching fraction. The main objectives of this study were to compare water use of high-wire grafted tomato grown with and without supplemental lighting and to evaluate the impact of light qualities and light sources [traditional overhead high-pressure sodium (HPS) lighting lamps vs. light-emitting diode (LED) intra-canopy lighting towers] on several production parameters for a commercial tomato cultivar under a greenhouse environment. Leachate volume was measured on alternating days and daily water use (DWU) was calculated from each slab planted with a single plant, which was subtracted by evaporative water loss measured from a slab without a plant. The light treatments were composed of LED treatments receiving three different combinations of red (R), blue (B) and far-red (FR). Light treatments consisted of blue (100B:60R:0FR), red (0B:100R:0FR), 50% far-red (0B:100R:50FR), far-red (0B:100R:100FR), and HPS and unsupplemented controls. The DWU increased with crop development stages. All light treatments followed the same trend on DWU with the highest water use during the periods of fruit development to harvest initiation. Daily water use was highest for the HPS control and lowest for the unsupplemented control. Among the LED treatments, the highest DWU was observed in red (0B:100R:0FR), followed by far-red (0B:100R:100FR) and then blue (100B:60R:0FR). Variations in DWU were associated with leaf area, biomass production, and fruit yield. Fruit yield was similar between LED and HPS treatments, with the highest fruit yield obtained in far-red (0B:100R:100FR). Fruit cluster size increased with addition of FR to R. High DWU in HPS was attributed to increased evapotranspiration demand due to heat generation under the overhead HPS lamps compared to plants grown using LED. It is concluded that supplemental LED with red (0B:100R:0FR) and far-red (0B:100R:100FR) can reduce water use for greenhouse tomato production and produce as equal or better tomato yield and quality compared to HPS.

**Oral Presentations**

**Oral Session—Ornamentals/Landscape and Turf 2**

Moderator: Chris Marble
University of Florida, Mid-Florida REC

4:00–4:15 PM

**Selection, Evaluation, and Introduction of Betula spp. By the NDSU Woody Plant Improvement Program**

Todd West*
North Dakota State University, Fargo, ND

The North Dakota State University (NDSU) Woody Plant Improvement Program has been servicing the Northern Great Plains for over 60 years, beginning germplasm trial evaluations in 1954. The goals of the NDSU Woody Plant Improvement Program are selection, evaluation, and introduction of hardy superior woody plants for the landscape industry. In 1974, NDSU purchased an 80-acre (~32 ha) farm to be established as the NDSU Horticulture Research Farm near Absaraka, ND (Lat. 46.9859, Long: -97.3549). Evaluation plantings began in fall of 1974. The main portion of this research farm is the center 35-acre (~14 ha) plot dedicated as the NDSU Dale E. Herman Research Arboretum, which includes an extensive Betula spp. collection with plantings beginning in 1974. *Betula* (Birch) is an important ornamental tree for the northern climate. *Betula* is a small group of trees and shrubs found mainly in the cooler temperate regions of the northern hemisphere. Birches make beautiful specimen trees and also provide a light, filtered shade. Birch species vary in their susceptibility to insect attacks and cultivar selections should be resistant to insects such as the bronze birch borer (*Agrilus anxius* Gory.). Since 1974, four different subgenera with 21 different birch species (seven native to the United States), five hybrids and numerous commercially available cultivars have been evaluated at the NDSU Dale E. Herman Research Arboretum. Each species, hybrid, or cultivar was evaluated over multiple years with a minimum of three replicates of each for evaluation. Plants were evaluated for survivability, dieback, BBB susceptibility, habit, and foliage quality. Members of the subgenus Neurobetula (Costate birches—*B. chinensis*, *B. costata*, *B. davurica*, *B. ermani*, *B. nigra*, and *B. utilis*); Betula (Typical birches—*B. occidentalis*, *B. papyrifera*, *B. pendula*, *B. platyphylla*, *B. populifolia*, *B. pubescens*, and *B. pubescens var. litwinowii*); and Chamaebetula (Dwarf birches—*B. glandulosa*, *B. middendorfii*, *B. ovalifolia*, and *B. apoiensis*) had mixed performances with several of the species and/or cultivars performing very well. The subgenus Betulenta (Wintergreen oil birches—*B. lenta* and *B. grossa*) has overall good performance in USDA hardiness zone 3b. Five cultivar releases have been made from birch evaluations by the NDSU Woody Plant Improvement Program including: *B. platyphylla* ‘Fargo’ (1996, Dakota Pinnacle® Asian White Birch), *B. papyrifera* ‘Varen’ (2002, Prairie Dream® Paper Birch), *B. platyphylla* ‘Verdale’ (2002, Prairie Vision™ Asian White Birch), *B. nigra* ‘Dickinson’ (2006, Northern Tribute® River Birch), and *B. costata* ‘CinnDak’ (2014, Cinnamon Curls® Dwarf Korean Birch).

4:15–4:30 PM

**Landscape Potential of Rare Species of Dirca Assessed at Five Sites Across the United States**

William R. Graves*
Iowa State University, Ames, IA

*Dirca* L. (leatherwood) species are aesthetically appealing North American shrubs, but their usefulness in horticulture will depend on the environmental conditions under which they thrive. In this study, two narrowly endemic species of leatherwood...
An asterisk (*) following a name indicates the presenting author.

4:30–4:45 PM

**Florida-Friendly Landscaping™: Promoting Biodiversity in the Urban Environment**

Esen Momol*
University of Florida, Gainesville, FL

Gail Hansen
University of Florida, Gainesville, FL

Don Rainey
University of Florida, Gainesville, FL

Claire Lewis
University of Florida, Gainesville, FL

John Bossart
University of Florida, Gainesville, FL

The state of Florida conducts a landscaping-based water quality and conservation program whose principles offer many avenues for water resources and biodiversity protection within built environments, both of which are emerging challenges in the continually developing Atlanta–Raleigh urban corridor. Florida’s current population of 20 million residents within 7.1 million households not only depletes available water resources and pollutes both surface and ground waters, but also leads to extensive changes in land use and land cover that have negative implications for biodiversity. To address these challenges, which will become even more acute as its population grows to nearly 26 million over the next 25 years, Florida has enacted a statewide program called Florida-Friendly Landscaping™ (FFL). The program provides educational outreach for science-based landscape design principles, maintenance and Best Management Practices (BMPs). Residential homeowners and commercial landscape workers use these principles and BMPs to create and maintain quality landscapes through appropriate landscape design, which reduces nonpoint source pollution through reduced water, fertilizer and pesticide use. Florida-Friendly Landscaping™ emphasizes landscape designs that call for appropriate plant selection (“right plant–right place”), functional turf use and proper irrigation system design and operation. Appropriate plant selection is the key to FFL’s success in that it promotes biodiversity while using less water, fertilizer and pesticides. An FFL-published plant guide facilitates landscape design and provides recommendations for plants appropriate to each of Florida’s diverse plant hardiness zones. The plant guide includes numerous ornamental and native species, especially those with value to wildlife, particularly birds and pollinating insects such as butterflies. The FFL plant recommendations recognize that turf grass is an appropriate landscaping choice when used in functional areas. FFL promotes environmentally friendly landscape designs that consist of trees, turf grasses, shrubbery, groundcovers, and mulch. When paired with an irrigation system that meets FFL specifications, an established FFL landscape requires only one-quarter the irrigation water as a traditional Florida landscape. Not only does this conserve water, but also reduces potential runoff or leaching of nutrients. UF/IFAS recommendations for proper fertilization rates also reduce potential nutrient losses. Integrated pest management (IPM) strategies that protect beneficial insects and pollinators further promote biodiversity. The University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) administers the FFL program in partnership with the Florida Department of Environmental Protection.

4:45–5:00 PM

**Drought and Heat Promote Macrophomina phaseolina Infection in Impatiens hybrida**

Shaun Broderick*
Mississippi State University, Crystal Springs, MS

Clarissa Balbian
Mississippi State University, Mississippi State, MS

Maria Tomaso-Peterson
Mississippi State University, Mississippi State, MS

Impatiens rank second only to petunias in bedding plant sales and are worth $170 M wholesale in the US. Although impatiens have traditionally had little disease pressure in the United States, in 2004 downy mildew (Plasmopara obducens J. Schröt.) had been reported on *Impatiens walleriana* Hook.f., and by 2011 it had spread worldwide and presented a major threat to the commercial production of impatiens. From 2009 to 2014, total sales for all impatiens dropped nearly $30 M, likely in response to disease reports. Growers were encouraged to shift production from susceptible *I. walleriana* to resistant New Guinea impatiens.
and their interspecific hybrids (*Impatiens hybrida Hort.*). Since then, U.S. sales for New Guinea impatiens have increased from 34.5% of the total impatiens market in 2009 to 46.2% in 2014. Here we report a new devastating disease affecting hybrid New Guinea impatiens. *Macrophomina phaseolina* (Tassi) Goid. devastated eight cultivars of New Guinea-type impatiens at the Truck Crops Branch Experiment Station in Crystal Spring, MS. Plants performed well during the season; however, near the end of July they developed stem cankers and died within a 2- to 3-week period. Plants tested negative for *Phytophthora*, but Koch’s postulates and DNA ITS sequencing confirmed *M. phaseolina* as the causal pathogen. Subsequent growth chamber studies of inoculated impatiens demonstrated that environmental factors of heat and drought promote the development of disease symptoms. Fourteen-hour daytime temperatures of 36.7 °C and ten-hour nighttime temperatures of 24 °C induced stem canker growth and expansion. At low day and night temperatures of 22 °C and 20 °C, stem cankers did not develop at inoculation sites. *Macrophomina phaseolina* was able to infect both wounded and unwounded stems, but stem cankers only developed on unwounded stems when grown at high temperatures. Drought conditions also played a role in promoting pathogenicity, but to a lesser extent than temperature. Further research will be needed to determine management practices that are suitable to landscape settings. This fungal pathogen is found worldwide in various agricultural and horticultural settings. The Systematic Botany and Mycology Laboratory Fungus–Host Distributions Database has over 1500 reports of charcoal rot worldwide on nearly 300 genera including corn, cotton, soybean, petunia and begonia. As global temperatures rise, the occurrence of this disease may become more prevalent and problematic to impatiens and other horticulturally important crops.

5:00–5:15 PM

**Safety of Preemergence Herbicides Applied during Propagation of Three Woody Nursery Crops**

Chris Marble*

University of Florida, Mid-Florida REC, Apopka, FL

Annette Chandler

University of Florida, IFAS Mid-Florida REC, Apopka, FL

Currently there are no preemergence herbicides labeled for use during propagation of ornamental crops. In propagation, weed control can be one of the most expensive production problems during due to lack of herbicide options. Weeds compete with cuttings for water, light, nutrients, and also significantly reduce the marketability of liners. Once weeds have begun to germinate in propagation flats the only method of removal is typically hand weeding which is extremely expensive from a labor standpoint and can also disrupt or delay the rooting process as the cuttings are often disturbed. Past research has shown varying levels of success with multiple species-herbicide combinations at different stages of propagation. The objective of this study was to investigate the impacts of herbicides on rooting and quality of three woody nursery crops. Four different herbicides were evaluated for use during propagation of *Loropetalum chinense* ‘Sizzling Pink’ (loropetalum), *Viburnum odoratissimum* (viburnum), and *Rosa ‘Radrazz’* (rose) in various combinations. Loropetalum cuttings were treated with Marengo G (indaziflam), Rout (oxfluorfen + oryzalin), or Tower (dimethenamid-p), viburnum cuttings were treated with either Gallery SC (isoxaben), Rout, or Tower, and rose cuttings were treated with either Marengo G or Gallery SC. All herbicide treatments were applied at 0.5, 1, or 2x their label rate. For rose and loropetalum, herbicide treatments were either applied 14 days before sticking (DBS), on the day of sticking (0 DAS), or at 30 or 60 DAS. Viburnum cuttings were treated at 14 DBS, and at 0, 30, 60, and 90 DAS. Data collected included phytotoxicity ratings at 1, 2, and 4 weeks after treatment and shoot and root fresh weights at study conclusion. Herbicide rate had little impact on trial results. Loropetalum cuttings performed best when treated with Marengo G at either 30 or 60 DAS in which there were no significant reductions in shoot or root FW, although there was a numerical reduction in shoot and root weight. For rose, cuttings performed best when treated with the lowest two rates of Gallery SC or Marengo at 30 and 60 DAS. For viburnum, cuttings grew similarly to non-treated controls when Gallery SC was applied at 14 DBS, 0 DAS, and 90 DAS. Viburnum cuttings were also similar to non-treated controls when Rout was applied at 14 DBS, 0 DAS, and 90 DAS. Viburnum cuttings were most impacted by applications of Tower, which reduced shoot and root FW at most timings.

5:15–5:30 PM

**National Grass Trial Results from Eight States with 22 Cultivars, 2012–2015**

Mary Hockenberry Meyer*

University of Minnesota, Chaska, MN

Barbara Fair

North Carolina State University, Raleigh, NC

Cynthia B. McKenney

Texas Tech Univ, Lubbock, TX

Brent Pemberton

Texas A&M Agr. REC, Overton, TX

Matthew D. Taylor

Longwood Gardens, Kennett Square, PA

Pamela Bennett

Ohio State University Extension, Springfield, OH

James Klett

Colorado State University, Fort Collins, CO

Alan Shay

Oregon State University, Corvallis, OR

Kimberly Moore

University of Florida/IFAS, Fort Lauderdale, FL

Leonard Perry

University of Vermont, Burlington, VT

Jane Rozum

Colorado State University, Castle Rock, CO

An asterisk (*) following a name indicates the presenting author.
Eight states (Colorado, Minnesota, North Carolina, Ohio, Oregon, Pennsylvania, Texas, and Vermont) completed three years of landscape evaluation of 17 switchgrass (Panicum virgatum) and five little bluestem (Schizachyrium scoparium) cultivars. Four locations in Florida (Fort Lauderdale, Fort Pierce, Quincy, and Wimauma), one in Nebraska, and two in Texas (San Marcos and Lubbock) completed one or two years of the trials. The establishment year was 2012 and the following 3 years: 2013–15 were data collection years. All sites compiled data on plant height; width; flowering time; fall color; winter interest; pests; foliage color determined by Royal Horticultural Society’s color chart; plant form rating 1–5; flowering date; floral impact rating 1–5; fall color; self-seeding rating 1–3–5; winter injury rating 1–3–5; pests; overall landscape impact rating 1–5; and mortality. Texas A&M Overton, Florida (4 locations), and Vermont had the highest mortality rate. Florida locations lost nearly 50% of their plants by the second year. There was wide variation in the overall landscape value in different regions of the country, with only five of the 22 switchgrass cultivars receiving high ratings. Highest scoring switchgrass cultivars for overall landscape value (4.0 or higher using a 5.0 scale) at 4 or more locations were Cloud 9, Dallas Blues, Northwind, Shenandoah, and Thundercloud. Only one of the five little bluestem cultivars, Blue Heaven®, rated 4.0 or higher at four or more locations for overall landscape value. This evaluation shows the range of variability in plant performance across the country and the need for more trials evaluating perennials across North America.

Oral Presentations

5:30–4:45 PM

Comparison of Fresh, Paraffin-based, and Resin-based Techniques for Sectioning Bark of Dirca L.
Zachary J. Hudson*
Iowa State University, Ames, IA
William R. Graves
Iowa State University, Ames, IA
Tracey M. Stewart
Iowa State University, Ames, IA
Harry T. Horner
Iowa State University, Ames, IA

 Shrubs in the genus Dirca L. (leatherwood) are notable for their horticultural potential, botanical status in North America, and history of ethnobotanical use. They are the only members of the Thymelaeaceae native to the United States and develop unusual arboreous growth forms and colorful flowers and leaves. Products of use to humans have been made from the strong, pliable, and tear-resistant bark of leatherwoods, and observations suggest forest-dwelling animals also harvest bark for functional use. As part of a more comprehensive analysis of the bark of leatherwoods, we evaluated various techniques for preparing sections of bark tissues for histological characterization. Analysis of techniques was necessary because previous reports of the stem anatomy of Dirca do not describe methodology, and sectioning techniques recommended for bark tissue were not effective. We found that the bark of Dirca comprises strata of bast fibers and non-lignified, thin-walled parenchyma; creating high-quality sections of tissue for anatomical analysis is difficult in part because of the heterogeneous composition of cell types. Three techniques developed specifically for heterogeneous plant tissues were used to section the bark from four-year-old stems of D. mexicana Nesom & Mayfield, which we used to represent the genus. Embedding with LR White resin led to slides of sectioned bark tissue of better quality than slides of tissue sectioned while fresh or after embedding in paraffin. The use of LR White resin best prevented damage or folding of tissue during sectioning and mounting. We conclude that the anatomical study of the heterogeneous cell composition of bark of D. mexicana is facilitated by use of LR White resin to embed fixed samples.

Oral Session—Pomology 3
Moderator; Zachary T. Brym
Utah State University, Logan, UT
4:15–4:30 PM

The Fruiting Wall Orchard: Tree Training Results for Sweet Cherries, Nectarines, Apricots, and Plums
Gregory A. Lang*
Michigan State University, East Lansing, MI

The evolution of stone fruit orchards from low density, stand-alone trees to high density, trellised tree walls has several driving forces: more uniform canopy light distribution, more uniform fruit development, labor efficiencies for thinning and harvest, potential mechanization of some pruning tasks, and better protective spray distribution, to name a few. Research trials on canopy architectural development and management have been carried out since 1999 on sweet cherry (Prunus avium L.), and since 2012 on nectarine (P. persica), apricot (P. armeniaca), and interspecific plum (P. salicina-based) hybrids. The most recent sweet cherry trial, part of the NC140 regional rootstock research project, examines the interaction of several canopy architectures, including Tall Spindle Axe (TSA), Upright Fruiting Offshoots (UFO), and Super Slender Axe (SSA), with precocious rootstocks that impart varying levels of vigor: dwarfing Gisela (Gi) 3, semi-dwarfing Gi 5, and semi-vigorous Gi 6. The other stone fruit species tend to be more naturally precocious than sweet cherry, but do not have comparably vigor-limiting rootstocks, thereby placing greater emphasis on canopy training to contain vigor within the fruiting wall framework. Depending on species, these stone fruits have been managed as TSA, UFO, SSA, or Palmate (PLM) canopies. Cumulative sweet cherry yields through Year 6, based on trial yields recalculated to suitable orchard tree spacing, were highest for TSA/Gi3, followed by UFO/Gi3 and UFO/Gi5. Although early yields were relatively high for SSA/Gi6, by Year 6 these had the lowest cumulative yield. Picking efficiency was 39% higher for the UFO fruiting
Modeling Dormancy for Changing Crop Suitability

Denise Neilsen*
Agriculture and Agri-Food Canada, Summerland, BC, Canada
Paul Wiersma
Agriculture and Agri-Food Canada, Summerland, BC, Canada
Rebecca Darbyshire
University of Melbourne, Tatura, Australia
Gerry H. Neilsen
Agriculture and Agri-Food Canada, Summerland, BC, Canada
Tom Forge
Agriculture and Agri-Food Canada, Summerland, BC, Canada
Gaëtan Bourgeois
Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC, Canada

The minimum winter temperatures and lack of in-season heat that limit the northern distribution of sweet cherry production have changed sufficiently over the past five decades to allow northward and upslope expansion of growing areas in British Columbia, Canada. There is considerable interest in projecting changing crop suitability into the future and we have combined a series of dormancy, cold hardiness, phenology and in season fruit growth models for sweet cherry to explore changing locations for sweet cherry production. A key component of this process is the use of temperature driven models for dormancy induction, completion of endodormancy and ecodormancy. We compare various methods of computing chilling and forcing (heating) temperatures tested for ‘Lapins’ and ‘Sweetheart’ sweet cherry cultivars using bud sticks sampled from the field over the fall and winter and forced in the greenhouse and in-field samples over 6 years. Observations in the greenhouse of flower quality (broken buds continue to develop up to bloom) and the percentage of flower buds that break indicate that endodormancy completion is not adequately described by a single chill value. This has been demonstrated in chill overlap models in which chilling and forcing together contribute to the success of broken buds after initial chilling requirements have been met. A study of the underlying molecular mechanisms has been initiated with RNA-Seq libraries detailing gene expression across the entire winter season. In addition to identifying temporal markers that correspond to dormancy transitions, there is also a striking drop in expression of specific cell cycle regulators (cyclins and cyclin dependent kinases) that persists after initial chilling requirements are met.

Near-harvest Irrigation Withholding

Todd C. Einhorn*
Oregon State University, Hood River, OR
Matthew Whiting
Washington State University, Prosser, WA
Ambroise Sarret
AgroSup, Dijon, Cedex, France

The effects of near-harvest irrigation on sweet cherry (Prunus avium L.) fruit quality are not clear. Deficit irrigation during the final stage of fruit growth has been associated with a loss of fruit size. On the other hand, producers have observed fruit softening from irrigation events applied too close to harvest. We evaluated the effects of withholding irrigation for varying pre-harvest durations on sweet cherry yield, fruit growth, stem water potential, gas exchange, fruit quality and cracking susceptibility. In 2014 and 2015, irrigations were withheld from nine and ten-year-old ‘Skeena’ or ‘Sweetheart’ trees for 15, 10, or 5 days prior to harvest and compared to well-watered controls. In both years, yields were unaffected by withholding irrigation treatments, irrespective of the duration or cultivar. Fruit growth was reduced by withholding irrigation for 10 or 15 days prior to harvest, but only when stem water potential reached values ≤ –1.5 MPa around 5 days from harvest. Small fruit size was associated with lower relative water content but not reduced dry matter. Photosynthesis rate was unaffected by withholding treatments so long as stem water potential remained above –1.5 MPa. Fruit firmness was reduced but not significantly when irrigation was withheld for 10 or 15 days. Skin color, soluble solids concentration and titratable acidity remained unaltered by withholding treatments. Fruits from trees that sustained stem water potentials < –1.5 MPa had 50% less cracking when evaluated using a bench-top immersion assay. Overall, irrigation withholding 5 days prior to harvest was not deleterious to sweet cherry fruit growth or quality. Longer periods of withholding require monitoring tree water status.

Near-harvest Irrigation Withholding

Tom Forge
Agriculture and Agri-Food Canada, Summerland, BC, Canada
Gaëtan Bourgeois
Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC, Canada

The effects of near-harvest irrigation on sweet cherry (Prunus avium L.) fruit quality are not clear. Deficit irrigation during the final stage of fruit growth has been associated with a loss of fruit size. On the other hand, producers have observed fruit softening from irrigation events applied too close to harvest. We evaluated the effects of withholding irrigation for varying pre-harvest durations on sweet cherry yield, fruit growth, stem water potential, gas exchange, fruit quality and cracking susceptibility. In 2014 and 2015, irrigations were withheld from nine and ten-year-old ‘Skeena’ or ‘Sweetheart’ trees for 15, 10, or 5 days prior to harvest and compared to well-watered controls. In both years, yields were unaffected by withholding irrigation treatments, irrespective of the duration or cultivar. Fruit growth was reduced by withholding irrigation for 10 or 15 days prior to harvest, but only when stem water potential reached values ≤ –1.5 MPa around 5 days from harvest. Small fruit size was associated with lower relative water content but not reduced dry matter. Photosynthesis rate was unaffected by withholding treatments so long as stem water potential remained above –1.5 MPa. Fruit firmness was reduced but not significantly when irrigation was withheld for 10 or 15 days. Skin color, soluble solids concentration and titratable acidity remained unaltered by withholding treatments. Fruits from trees that sustained stem water potentials < –1.5 MPa had 50% less cracking when evaluated using a bench-top immersion assay. Overall, irrigation withholding 5 days prior to harvest was not deleterious to sweet cherry fruit growth or quality. Longer periods of withholding require monitoring tree water status.
istics, canopy dimensions, light, yield, and fruit sugar content were quantified. Overall, smaller trees produced marginally more fruit with significantly higher sugar content. Trees with larger trunk cross sectional area given their age tended to produce more fruit but with lower sugar content. Sugar content was improved by trees with higher yield efficiency and also by trees with relatively larger and less dense canopies facilitated by height and spread dimensions, but not canopy volume. Light distribution within the canopy was only weakly correlated with fruit sugar content, but provided evidence suggesting canopy volume in current commercial plantings quickly becomes too large or overly dense. Tart cherry may be well-suited for planting in high-density systems as precocious trees maintained for two-dimensional canopies with slender and young fruiting branches will facilitate high yield efficiency and fruits of high sugar content.

5:15–5:30 PM

**Evaluating Fruit Quality and Maturity in Large Open Vase-trained ‘D’Anjou’ Trees**

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Commercial pear trees in the Pacific North West are still primarily low density systems with multi-leader, globe shaped canopies usually with an open center to allow light penetration. Rootstocks are limited to mainly seedlings, leading to highly vigorous trees. Trees height can reach 5 m with a very large canopy volume where fruit are mostly in the upper-medium portion of the canopy. Fruit characteristics inside such a vigorous tree can be very diverse because their exposure to light is variable within the canopy. This system has several disadvantages including highly variable maturity and internal quality within the canopy of the same tree. A ‘d’Anjou’ pear commercial orchard located in WA and grafted on Bartlett seedlings in the 1970s with a planting density of 278 trees/ha was object of this study. A portable spectrometer was used to quantify light intensity in the different horizontal layers within 15 similar canopies in the same orchard. Fruit were classified into two canopy positions as internal (< 30% light) and external (70% to 100% light) and were harvested separately. Fruit were further sorted according to the \( I_{\text{max}} \) index and classified into 5 classes. Fruit maturity distribution within \( I_{\text{max}} \) classes at harvest was different within each canopy position. Nearly 28% of external fruit were from the most ripe category, while only 0.7% of internal fruit were in that class. Fruit from each class were randomized and subdivided into 4 groups: T0 (= after harvest, no storage) and three pull outs (3, 6, and 8 months) from controlled atmosphere (CA, 0.5 °C, 2 kPa \( O_2 \) and 0.8 kPa \( CO_2 \)) storage. Fruit quality was assessed at each pullout including percentage of blush over-color surface, background color, exogenous ethylene, weight, firmness, fruit diameter, cork spot incidence, dry matter %, soluble solid content, acidity and pH. External fruit were larger, riper, and had a higher dry matter % and SSC than internal ones after 8 months of CA storage. The results indicate fruit position within these trees has a considerable impact on d’Anjou’ pear internal quality and storability.

5:30–5:45 PM

**Performance of Pear Rootstocks in North America**

Jaume Lordan*
Cornell University, Geneva, NY

Terence Lee Robinson
Cornell University, Geneva, NY

Suzanne Blatt
AAFC-Kentville, Government of Canada

Poliana Francescatto
Cornell University, Geneva, NY

Charles Embree
Agriculture and Agri-Food Canada, Kentville, Nova Scotia, Kentville, Canada

The adoption of high-density orchards during the last decades has resulted in a significant improvement in yield and fruit quality. However, the late full production achievement is still one of the main challenges when planting a pear orchard. In addition, winter damage and fire blight can also compromise viability, especially in cool humid areas like North America. For instance, quince rootstocks in North America have not been used due to the possibility of winter damage, fire blight and pear decline. In 2004, a field trial was planted at three locations: Geneva, NY; Rockland, Nova Scotia; and Kentville, Nova Scotia. The trials compared three Pyrus rootstocks: Old Home x Farmingdale (OHF) 97, OHF87 and Pyrodwarf with ‘Taylor’s Gold Comice’ and ‘Concorde’ pear as the scion cultivars. Trees were trained as central leaders with 2 tiers of branches, with branches spread to 70° to 90° from vertical in the third year. Tree spacing was 2.5 m x 4.5 m. The trial at Geneva and the trial at Rockland were managed with conventional pesticides and fertilizers while the trial at Kentville was managed using organic strategies. After 12 years of growth, trees with OHF97 and OHF87 were the most vigorous under conventional management, whereas Pyrodwarf and OHF87 performed better than OHF97 under organic strategies. Cumulative yields were highest from ‘Concorde’ compared with ‘Taylor’s Gold Comice’. There were no significant differences in yield efficiency among the three rootstocks, and fruit size was generally smaller with Pyrodwarf, which also had the most suckers. Results from this study show that Pyrodwarf does not offer any significant advantage over the OHF stocks.

An asterisk (*) following a name indicates the presenting author.
Peach Fruit Bagging in the Southeastern United States

Jaine Allran*
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Guido Schnabel
Clemson University, Clemson, SC

Juan Carlos Melgar
Clemson University, Clemson, SC

Peach growers must control many pests and diseases to be able to produce high-quality peaches under the humid conditions of the southeastern U.S. Fruit bagging is proposed as a strategy to exclude pests and diseases, reduce reliance on insecticide and fungicide applications, and produce high-quality peaches.

Two farms were selected, one using conventional methods of pest and disease management, and another one using certified organic methods. At each farm, ten peach trees of two cultivars with different ripening seasons (early-season and mid-season) were selected, 150 fruit per tree were bagged at thinning time (beginning of April) and the rest were left without bags. Fifty bags per tree were removed ten days before harvest to determine its effect on fruit color. Thus, three treatments were performed on each tree: 1) control (non-bagged) fruit; 2) bagged fruit (until harvest); and 3) unbagged fruit. Fruit quality analyses [size, weight, soluble solid content (SSC), titratable acidity (TA), and SSC/TA ratio] and disease assessments at harvest and postharvest were performed. Bagging increased fruit recovery by 29% and reduce postharvest brown rot incidence at the organic farm (there was no brown rot in the conventional farm). Fruit quality analyses at both farms showed similar or higher fruit size in bagged fruit than in control fruit (although this did not cause a difference in fruit size category). No differences in SSC, TA or SSC/TA ratio between treatments were found. Bagged peaches developed red blush although less intense than control peaches; however, unbagging increased the intensity of the blush and color of unbagged peaches was comparable to that of control peaches. Consumer surveys showed that the majority of consumers would prefer bagged peaches after they were informed they were produced inside bags and received essentially no pesticide application. Most consumers were willing to pay a premium for bagged peaches. Based on these results, this technique has a great potential to produce a high-quality and low-residue peach that could be sold for a premium in certain markets while reducing pesticide applications in the Southeast.

Specified Source(s) of Funding: Southern IPM Enhancement Grants

Oral Presentations

Thursday, August 11, 2016

Oral Session—Vegetable Crops

Management 3

Moderator: Chris Benedict
Washington State University, Bellingham, WA

10:30–10:45 AM

Designing and Implementing Multi-dimensional Outreach Activities

Chris Benedict*
Washington State University, Bellingham

Carol Miles
Washington State University, NWREC, Mount Vernon

The Extension arm of the Land Grant University system was created in 1914 to provide scientists an avenue to disseminate information generated from research activities directly to grower and industry stakeholders. This presentation will discuss outreach activities associated with a recently funded USDA-NIFA SCRI project evaluating biodegradable mulches for vegetable production. Our SCRI team is comprised of 29 researchers and Extension personnel from three Universities, and is organized into six different working groups. From the outset of the project, we integrated outreach activities into each working group so that extension activities are prioritized and performed by research scientists throughout the course of the project rather than just occurring at project completion. Additionally, we assigned outreach activities into three major categories: 1) Introductory—legacy materials that are principle-based and provide an introduction to basic, fundamental concepts; 2) Intermediate—materials that provide mechanisms for application; and 3) Advanced—topic-specific materials. Within each category, outreach materials include website development, on-line videos (short segments, mobile-accessible) and training modules, webinars, Extension fact sheets, and peer-reviewed journal articles in applied science journals to disseminate new applied information. Within the first year of our SCRI project we created a new website www.biodegradablemulch.org where we can post new project information. Within the second year of the project we have written (and posted online) five fact sheets, one short introductory video (Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production: Project Introduction), and one PowerPoint slide presentation which includes preliminary results from our first year of field research. We will discuss the process that was utilized to develop the outreach portion of this project and the innovative outreach methods so that attendees can incorporate these ideas into their current research programs.

Specified Source(s) of Funding: USDA-NIFA SCRI Program
Using the GoPro InfraBlue22 Lens for NDVI Vegetable Measurements
Kurt Nolte*
University of Arizona, Yuma, AZ
Rosa Bevington
University of Arizona, Yuma, AZ
NDVI (Normalized Difference Vegetation Index) is a numerical indicator which uses the visible and near-infrared bands of the electromagnetic spectrum to assess plant vigor. And, the NDVI index has been integrated into remote sensing environments using various camera systems mounted on Unmanned Aerial Vehicles (UAVs) to assess the health and stress of crop plants. When using this technology, growers would be able to visualize the areas of the field that are stressed and, perhaps, rapidly mitigate a potential problem. The GoPro camera has gained general acceptance in UAV platforms due to its relatively low cost, lightweight and ability to shoot incredibly high-quality footage/still reliably. While any consumer camera can collect blue, green, and red bands, capturing the NIR band for calculating a standardized NDVI index requires wavelength separation and subsequent spectral analysis of individual bands, not a simple lens replacement. The GoPro InfraBlue22 (IR Pro) lens system captures NIR, Green and Blue spectra and when used in conjunction with UAV platforms, it is interpreted as “pseudo-NDVI” by many agronomists. Our effort explored the use of a GoPro InfraBlue 22 lens system to assess field level, pseudo-NDVI measurements. Our work suggests that UAVs with GoPro InfraBlue can be viewed as an accompanying tool in precision agriculture, which creates actionable data by the user. Using a consumer UAV and flying a NDVI converted camera offers producers an inexpensive “first look” with a short return on investment. The system, in some cases, generates actionable data and can identify vegetation and crop stress, which can be correlated to ground data. Inexperience workers can be trained relatively easily to take the first steps into using aerial imagery through the use of UAVs.

Vegetable Plant Stand Counting: Using RGB and NIR Cameras
Rosa Bevington*
University of Arizona, Yuma, AZ
Kurt Nolte
University of Arizona, Yuma, AZ
With Aerial imagery and UAV (unmanned aerial vehicles) technology increasing, finding field applications has been an eagerly accepted challenge. Naturally, there has been much interest in combining this technology with the agriculture industry. One thing we aim to simplify is assessing plant stand counting. Generally, estimating stand counts would use a manual measurement technique by physically counting plants within small plots. We are able to assess these fields via the use of aerial images to save time and labor. There are now a variety of cameras that are available for use with a UAV. We compared a visual camera (red blue green wavelengths) with a Near Infrared camera using NDVI (Normalized Difference Vegetation Index) to determine stand counts to benefit growers. We evaluated the altitude required for stand counting while at the same time considered battery use efficiency and post flight image processing. While using the RGB and NIR cameras, we were able to determine stand counts and other key parameters from the crop (ex. size, shape and area). Although the RGB camera does not provide the same level of detail as the NIR wavelength, RBG does allow stand counting in certain conditions. We believe that capturing the NIR wavelengths is a superior method for its ease of processing and future benefits as technology increases. We feel that these approaches could benefit growers and enable them to quickly problem solve.

Low-temperature Exposure at Early Foliar Stages Affects Both Cauliflower Head Initiation and Development Rate
Gaetan Bourgeois*
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Stéfanie Larocque-Desroches
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Andréeanne Ferland
Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC, Canada
Maxime Beaudoin-Galaise
Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC, Canada
Planning a harvest schedule for some cultivars of cauliflower is a complex task because they require exposure to temperatures below 15°C for the production of their inflorescences. However, it is not clearly understood when and how long this exposure at such lower temperatures should occur during the course of their phenological development. A previous study showed that exposure at the 3-leaf stage delayed head initiation and exposures at 5 to 13 leaf stages promoted head initiation. The objective of this study was to determine the minimum required exposition time at temperatures between 2.5 and 15.0 °C for promoting head initiation. In order to determine these minimum exposition times, cauliflower seedlings (cultivar ‘Casper’) were produced in greenhouse and exposed at the 9 leaf stage to temperature of 2.5 °C, 5.0 °C, 7.5 °C, 10.0 °C, 12.5 °C, and 15.0 °C during 2, 4, 6, 8, 10, and 12 days in growth chambers, and then returned to the...
greenhouse, in which the temperatures were set at 22°C during the day (16 hours) and at 18°C during the night (8 hours). The phenological stage of each plant was evaluated at least twice a week in the greenhouse and in growth chambers. Plant height and head diameter were measured once and twice a week, respectively. With respect to the optimum exposure time for each of the temperatures tested, the shorter periods do not appear optimal for earlier head initiation and faster head development rate of the ‘Casper’ cauliflower cultivar. Exposure times of 8 to 12 days at temperatures of 5.0 °C, 7.5 °C, and 10.0 °C resulted in the earliest head initiations and fastest head development rates. However, regardless of the exposure temperature and duration at the 9-leaf stage for this cultivar, all treatments had a positive effect on head initiation and development rate. Such information will be integrated in a weather based dynamic phenology model in order to assist vegetable producers to improve their field planning of cauliflower transplantation and harvest.

11:30–11:45 AM

**Effects of Post-anthesis Detasseling on Sweet Corn Yield**

Rebecca Brown*
University of Rhode Island, Kingston, RI

Prevention of bird damage to maturing sweet corn ears has become a major challenge for peri-urban vegetable producers in New England. The primary pests are large flocks of starlings, grackles, blackbirds, and crows. Propane cannons are the most common control method, as they are easily moved between planting blocks of sweet corn and require minimal labor. However, the cannons are extremely unpopular with non-farm neighbors, due to the incessant noise. Anecdotal reports and unreplicated on-farm trials have suggested that bird damage to maturing sweet corn ears can be reduced or eliminated if the tassels and upper leaves are removed after pollination. Sweet corn grown for processing in the Willamette Valley of Oregon is routinely detasseled after pollination to speed maturity and reduce lodging of plants following heavy rains. Detasseling does not affect yields of the standard processing cultivar, Jubilee, but it has been reported to reduce yields of other cultivars. Growers may be willing to adopt detasseling if it prevents bird damage without negative effects to sweet corn yields or quality, but they are unlikely to accept the added costs of detasseling if the practice also reduces marketable yields. The objective of this study was to determine how detasseling affects the fresh market sweet corn cultivars popular with growers in southern New England. Sixty cultivars, blocked by market class and maturity date, were planted in four replications in Summer 2015 at the Gardiner Crops Research Farm in Kingston, RI. Tassels were removed from half the plants in each plot by cutting the stalk two nodes above the top ear 5–7 days after silking. Corn was harvested by hand from each subplot, and data were collected on yield. Detasseling significantly reduced yield. By weight yields from detasseled plants were only 85% of the control yields, and number of marketable ears was only 89% of the control. Effects were consistent across all cultivars. Detasseling also significantly increased the incidences of poor tip fill and incomplete pollination, with the supersweet cultivars being more strongly affected. Detasseling does not appear to be a viable alternative to propane cannons for preventing bird damage, as it would increase costs while decreasing yields on a crop with low profit margins.

**Specified Source(s) of Funding:** Specialty Crop Block Grants, RI Division of Agriculture

11:45–12:00 PM

**Deterioration of Biodegradable Plastic Mulch in Pumpkin Production in Northwest Washington**

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Ed Scheenstra
Washington State University, NWREC, Mount Vernon, WA
Jeremy Cowan
Washington State University, Spokane, WA
Henry Sintim
Washington State University, Puyallup, WA
Markus Flury
Washington State University, Puyallup, WA
Debra A. Inglis
Washington State University, Mount Vernon, WA
Carol Miles
Washington State University, NWREC, Mount Vernon, WA

Use of polyethylene (PE) mulch has become a standard practice in vegetable production around the world. However, removal and disposal of used PE mulch can be costly and PE fragments often become a source of pollution to the soil and environment. Mulch that can function similarly to PE mulch but biodegrades in the soil after tillage incorporation within a year or two, without negative environmental impacts, would be a sustainable alternative to PE mulch. In 2015, a field study at Mount Vernon, WA evaluated four potentially biodegradable mulches (Metabolix, Organix, Naturecycle and BioAgri) for above-soil deterioration during a pumpkin (Cucurbita pepo L.) cropping season and in-soil biodegradation after tillage incorporation. Cellulose mulch (100% biodegradable) and PE mulch (non-biodegradable) were included as positive and negative control treatments, respectively. Percent soil exposure (PSE) (where 0% PSE indicated intact mulch and 100% PSE indicated completely deteriorated mulch) at the end of the growing season was high for Naturecycle (61.3%) and low for PE (0.3%), Metabolix (1.2%), WeedGuardPlus (2.5%), Organix (3.5%) and BioAgri (8%) (P < 0.0001). To measure in-soil biodegradation after soil incorporation, we collected five soil samples (15.24 cm deep and 10.16 cm diameter (total 6178 cm³)) from each plot and extracted mulch fragments to establish a baseline measure of mulch per unit volume of soil. Mulch fragments were weighed (‘dirty weight’), cleaned, dried and weighed again (‘clean weight’), and the mulch area per plot was calculated as clean weight per plot over the weight per unit area of the mulch. Weight per unit area of mulch was calculated...
by measuring the area and weight of ten relatively intact mulch pieces. Percent mulch extracted was calculated by dividing total area of recovered mulch fragments by the theoretical maximum mulch area. The theoretical maximum mulch area (405 cm²) was calculated as the surface area of a sub-soil sample multiplying by 5 (number of sub-samples per plot). Percent mulch extracted for the baseline measurement was highest for PE (61.3%), followed by Metabolix (56.3%), Organix (54.4%), and BioAgri (47.8%), and was lowest for Naturecycle (13.8%) and WeedGuardPlus (25.3%) ($P = 0.03$). Over the next 4 years, each mulch will be re-layed, cropped, and then tilled into each respective plot; PSE

An asterisk (*) following a name indicates the presenting author.
confirmation of DNA test predictiveness have been performed on limited germplasm sets. Thus were born “DNA test cards,” a standardized, hand-held format for DNA-based trait-predictive tools made available to Rosaceae crop breeders by the USDA-NIFA-sponsored project, RosBREED. The following elements are found on each DNA test card: 1) a descriptive name for the test and its target; 2) brief information on the trait’s importance in a breeding context; 3) a “Genetics” section summarizing the mode of inheritance for the trait and specific loci targeted by the DNA test; 4) “Alleles Available,” illustrating the predicted effects and observed frequencies of the alleles, as well as example cultivars for common genotypes; 5) “When to Assay,” suggesting several ways the DNA test could enhance breeding operations; 6) “Predictive Capacity,” describing how much of the trait’s known genetic variation is expected to be captured, in germplasm tested so far; confirming effects in a breeding program’s own germplasm is always recommended; and 7) “Technical Details,” summarizing how many markers, what marker types, and how many loci are in the DNA test. Predictions of genetic potential can be used independently in breeding decisions or combined and weighed with outcomes of other tests. DNA tests described by these cards are therefore versatile tools supporting selection in modern crop improvement. DNA test cards are regularly updated to incorporate new information and distributed as printed cards within a brochure, and are also available online at www.rosbreed.org/breeding/dna-tests. The RosBREED project will continue to develop DNA test cards to deliver practical translations of genomics discoveries.

Specified Source(s) of Funding: Hatch funding to the Department of Horticulture, Washington State University

11:00–11:15 AM

Development and Characterization of a Molecular Marker Associated with Female Flowers in Muscadine Grape (Vitis rotundifolia)

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Muscadines have three flower types: hermaphroditic, male, and female. Male flowers have only filaments and anthers. In contrast, both female and hermaphroditic flowers are morphologically perfect, but female flowers have reflexed stamens (as opposed to upright) and non-functional pollen. At present, flower sex in muscadine is thought to be controlled by a single major locus with three alleles: M (male), H (hermaphrodite), and F (female) in the dominance relationship M > H > F, although this theory does not explain the existence of M progeny in some H x H crosses. Primers derived from previously identified candidate genes located at the sex locus of V. vinifera were used to generate amplicons from muscadine genotypes with differing flower types. Sequence analysis of the amplicons revealed an In/Del polymorphism in a trehalose-6-phosphate phosphatase (TPP) gene among genotypes. Primers were designed flanking the In/Del to examine the polymorphism in muscadine M, H, and F genotypes and in F x H, F x M, and H x H segregating populations. A co-dominant marker was developed that is able to differentiate the F allele from the M and H alleles. The marker is able to accurately predict the presence of female flowers. The use of the marker in muscadine breeding programs will be discussed.

11:15–11:30 AM

Vaccinium arboreum Is a Potential Source for Breeding Deeper Root Systems in Southern Highbush Blueberry

Gerardo H. Nunez*
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Hilda Rodriguez-Armenta
University of Florida, Gainesville, FL

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Growers use costly soil amendments to provide southern highbush blueberry (SHB, Vaccinium corymbosum hybrids) plants with an adequate soil environment for growth. SHB exhibits shallow, fibrous root systems that confine plant water and nutrient uptake to superficial soil layers. V. arboreum is a wild species native to the southeastern United States and has previously been used in SHB breeding. Field observations suggest that V. arboreum exhibits deeper root systems than those of SHB; however, this has not been documented. Plants that develop deeper root systems may exhibit increased drought and nutrient deficiency tolerances because they can access water and nutrients found in deeper soil strata. We hypothesized that a) V. arboreum seedlings exhibit deeper root systems than SHB seedlings and interspecific hybrids between SHB and V. arboreum exhibit intermediate phenotypes and b) DNA markers are associated with root system depth from V. arboreum. We tested these hypotheses using seedling families grown in bench-top rhizotrons filled with sphagnum peat moss. Root systems were cleaned and scanned prior to analyses with WinRhizo Pro 2013b. Comparisons of SHB, V. arboreum, and interspecific families with different levels of V. arboreum introgression indicated that V. arboreum exhibited greater maximum root depth and lower percentage of roots in the top 8 cm of soil than SHB. Interspecific hybrids generally exhibited intermediate root depths between SHB and V. arboreum. In a subsequent experiment, a pseudo-backcross 1 family of interspecific hybrids [SHB x (SHB x V. arboreum)] was phenotyped as above and genotyped through a genotype-by-sequence approach to search for markers associated with root system depth. A total of 3447
Development of Genomic Information in American Cranberry

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USDA-ARS, VCRU, Madison, WI

The application of genotyping by sequencing (GBS) approaches are excellent tools to characterize the genomic structure of recently domesticated (~200 years) and understudied species, such as cranberry (Vaccinium macrocarpon Ait.), by generating large numbers of markers for genomic studies such as genetic mapping. We identified 10842 potentially mappable single nucleotide polymorphisms (SNPs) in a cranberry pseudo-testcross population wherein 5477 SNPs and 211 short sequence repeats (SSRs) were used to construct a high density linkage map in cranberry. Of the estimated 470 Mb cranberry genome, Bin mapping identified 592 and 672 unique bins in the parentals, and a total of 1676 unique marker positions in the integrated map. Micro-synteny analyses comparing the order of anchored cranberry scaffolds to their homologous positions in kiwifruit, grape, and coffee genomes suggested initial evidence of homology. GBS data was used to rapidly saturate the cranberry genome with markers in a pseudo-testcross population. Collinearity between this saturated genetic map and previous cranberry SSR maps suggests that the SNP locations represent accurate marker order and chromosome structure of the cranberry genome. SNPs greatly improved current marker genome coverage, which allowed for genome-wide structure investigations such as segregation distortion, recombination, linkage disequilibrium, and synteny analyses. In the future, NGS can be used to accelerate molecular breeding through genome-wide association studies (GWAS) and genomic selection (GS).

Identifying Hurdles and Potential for Developing New Early Season Red Raspberry (Rubus idaeus L.) Cultivars in British Columbia

Michael Dossett*
B.C. Blueberry Council (in partnership with Agriculture and Agri-Food Canada), Pacific Agri-Food Research Centre, Agassiz, BC, Canada

Chaim Kempler
Agriculture and Agri-Food Canada (retired), Agassiz, BC, Canada

The raspberry breeding program in British Columbia is focused on the development of machine-harvestable floricanne-fruiting red raspberries for the processing industry. In recent years, growers and processors have expressed a desire for pushing the summer raspberry season earlier to reduce pressure from Spotted-winged Drosophila, as well as to reduce competition for space on processing lines with the rapidly growing blueberry industry. To better understand the feasibility of working toward the goal of developing new cultivars that are earlier than the current standard ‘Meeker’, we reviewed 20 years of data from yield trials conducted by the program and found a significant trend toward lower yield in early season selections than in later season selections. Further analyses showed that ripening season is likely to be highly heritable, but also showed a significant bias toward selections being later ripening than what would be predicted by their parents. Finally, most of the best sources of root rot tolerance in the program have a similar or later season than ‘Meeker’. These data suggest that moving the program
toward earliness will likely take at least 2–3 generations of concerted effort, that selection for large fruit size is likely to be a key part of maintaining yield in new early season selections, and that identifying and incorporating new sources of earliness, particularly those with root rot tolerance, will be a significant aid toward this goal.

12:00–12:15 PM

Post-release Performance of MP-29, an Interspecific Plum-pear Hybrd Rootstock for Peach

Thomas Beckman*
USDA-ARS, Byron, GA

José X. Chaparro
University of Florida, Gainesville, FL

Following the release of MP-29 rootstock in 2011, data collection has continued in both research and grower-cooperator trials. To date the performance of MP-29 in terms of its resistance to peach tree short life, Armillaria root rot and root-knot nematodes has exceeded expectations. Additionally, its horticultural performance both in terms of yield and fruit size, issues that have been problematic with other interspecific hybrids, has been excellent. Data will be presented on MP-29 and the next generation of rootstocks for peach now approaching release.

12:15–12:30 PM

Fruit Characters and Volatile Organic Components in Peach-to-Nectarine Mutants

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USDA-ARS, Fort Pierce, FL

William Okie
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Anne Plotto
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Peach-to-nectarine mutants showed broad pleiotropic effects on fruit size, taste, and aroma, in addition to hairlessness. In this study, we compared nine fruit attributes and 27 detected volatiles in the peach progenitor, ‘Flameprince’ (FPP), its two independently discovered peach-to-nectarine mutants (HFN and PFN), and a selected nectarine hybrid (SLN). HFN and PFN differed from FPP in fruit size and taste, but shared high similarities in fruit blush coverage and pattern, pit shape, and flesh and pit color. Compared to FPP, the two mutants were significantly lighter and smaller, but higher in soluble solids content (SSC), titratable acidity (TA), and the SSC/TA ratio. The 27 volatiles varied among the cultivars and harvest dates, in terms of total abundance and detection rate, which could be roughly clustered into six subgroups. Subgroup 1 included five volatiles and two fruit attributes that were low on Aug 6 but dramatically increased on Aug 13. Subgroup 2 had a similar tendency to subgroup 1 but one of the cultivars was an exception. Subgroup 3 included those that had the opposite tendency to subgroup 1 or 2. Volatiles in the three subgroups appeared closely associated with the ripening process. Fruit volatiles and attributes in the other three subgroups generally were inconsistent among the four cultivars on the two dates. Hexanol was the only volatile undetected in the peach, but detected in the three nectarines. Differences in broad pleiotropic effects among these mutants, potential utilization of volatiles, and genomic exploration are discussed.

Oral Session—Herbs, Spices, and Medicinal Plants 2

Moderator: Amanda Morgan
University of Florida, Mid-Florida REC, Apopka, FL

10:45–11:00 AM

Air Temperature Affects the Growth and Development of Cilantro, Dill, and Parsley

Chris Currey*
Iowa State University, Ames, IA

Jacob R. Smith
Iowa State University, Ames, IA

Kellie J. Walters
Iowa State University, Ames, IA

Culinary herbs are a popular crop for greenhouse and controlled-environment agriculture production. The yield (fresh mass) of herbs consists of foliage and, therefore, producers are interested in increasing the rate of leaf development and biomass accumulation to reduce the time to harvest and maximize yield. Our objectives were to quantify the effect of air temperature on the growth and development of cilantro (Coriandrum sativum L.; standard and heat-tolerant), dill (Anethum graveolens L.), and parsley (Petroselinum crispum (Mill.) Fuss). Seedlings from a 288-cell plug tray were individually planted into 10-cm-diameter containers filled with a commercial soilless substrate and transferred into environmental growth chambers with one of five target air temperature air temperatures of 11 °C, 17 °C, 23 °C, 29 °C, or 35 °C. Four weeks after placing plants into temperature treatments, plant height and node number were recorded. Plants were harvested and shoot fresh mass was recorded. Shoots were then placed in a forced air drier maintained at 67 °C for 3 days then weighed and dry mass was recorded. Data were analyzed using regression analyses. For node appearance rate and fresh mass accumulation rate, optimum temperatures (Topt) were estimated and base (Tbase) temperatures were calculated. Predictive linear models were then fit to the data between Tbase and Topt, within the linear range Fresh and dry mass accumulation rate for dill, standard cilantro, and parsley exhibited similar responses to air temperature. For example, the fresh mass accumulation rate increased by 0.69, 0.57, and 0.48 g/day as air temperature increased from 11.0 °C to 22.9 °C for standard cilantro, dill, and parsley, respectively, while the Topt for fresh mass accumulation was ~26 °C, 23 °C, and 23 °C, respectively. Alternatively, the

An asterisk (*) following a name indicates the presenting author.
fresh mass accumulation for heat-tolerant cilantro increased as temperatures increased up to 29.0 °C; T_{95} could not be calculated, though we speculate it is just above 29 °C, since fresh mass accumulation sharply decreased as temperatures further increased to 35.0 °C. Node appearance rate for standard cilantro, dill, and parsley followed a similar trend as fresh mass accumulation, increasing with temperature up to 22.9 °C, then decreasing as temperatures further increased, whereas node appearance rate for heat-tolerant cilantro increased by 0.61 nodes/day as temperatures increased to 29 °C. Predictive models for node appearance rate and fresh mass accumulation may serve as a decision-support tool for predicting development and yield of cilantro cultivars, dill, and parsley in response to air temperature.

11:00–11:15 AM

**Effect of Substrate and Fertilizer Application Rate on Growth of Tanacetum parthenium in a Protected Greenhouse Structure**

Amanda Morgan*
University of Florida, Mid-Florida REC, Apopka, FL

Brian Pearson
University of Florida, Mid-Florida REC, Apopka, FL

Richard Smith
University of Florida, Mid-Florida REC, Apopka, FL

*Tanacetum parthenium*, or feverfew, is a perennial, herbaceous flowering plant valued for its ornamental and medicinal properties. Native to Eurasia, but naturalized throughout the United States, feverfew is conventionally sold in human health and nutrition markets as a tea or dried encapsulated product to act as an anti-inflammatory agent and to reduce or eliminate migraine pain. Although much is known about the use of this plant, little information is available regarding its cultivation. The objective of this research was to quantify the influence of various substrate and fertilizer application rates on growth of feverfew within a protected greenhouse environment. To conduct this work, 72 feverfew seeds were purchased (Strictly Medicinal Seeds, Williams, OR), germinated in a greenhouse located in Apopka, FL, and transplanted on 8 Dec. 2015, into 3.8 L containers (Fafard 1P, FL, and transplanted on 8 Dec. 2015, into 3.8 L containers containing three commercial substrate mixtures (Fafard 1P Mix, Fafard 4P Mix, and Fafard 52 Mix). A slow release fertilizer (Osmocote 15–9–12) was applied at rate of 0, 1.6, 4.5, and 6.8 g·L^{-1}. Plant growth indices (width1 x width2 x height) were recorded weekly while substrate electroconductivity (EC) and pH of the growing substrate leachates were measured (pour-through) weekly, and the photosynthesis of plants were measured at the fourth and sixth week. The results showed that there were no significant differences in growth index, internode number, chlorophyll content and net photosynthesis rate among 100, 200 and 300 mg·L^{-1} N treatments for both sweet basil and perilla. The leachate EC differed among cultivars and species and treatments. During the six week experiment period, the average leachate EC in the 100, 200 and 300 mg·L^{-1} N treatments were 0.8 dS·m^{-1}, 1.7 dS·m^{-1}, and 2.6 dS·m^{-1} in ‘Gevenose’, while they were 0.7 dS·m^{-1}, 1.5 dS·m^{-1}, and 2.4 dS·m^{-1} in ‘Asia Ip’, and 0.9 dS·m^{-1}, 1.6 dS·m^{-1}, and 2.3 dS·m^{-1} in ‘Shiso Red’, respectively. Therefore, 100 mg·L^{-1} N concentration was the most suitable for the growth and development of ‘Gevenose’, ‘Asia Ip’, and ‘Shiso Red’.

11:30–11:45 AM

**Quercetin Regulation By PIRIN1 and Ultraviolet Light Can Boost Medicinal Properties of Seedlings of Medicinal Importance**

Hui Ni
University of Illinois at Chicago, Chicago, IL

Danielle Orozco-Nunelly
University of Illinois at Chicago, Chicago, IL

Ashley Williams
University of Illinois at Chicago, Chicago, IL

Carlos Montero
University of Illinois at Chicago, Chicago, IL

Shamaila Zaheer
University of Illinois at Chicago, Chicago, IL

Katherine Warpeha
University of Illinois at Chicago, Chicago, IL

Seed-to-seedling transition is a critical developmental time. In this stage, the photosynthetic apparatus becomes fully functional

An asterisk (*) following a name indicates the presenting author.
and seedlings start to produce defensive molecules. Quercetin is stored in the seeds, and young seedlings can synthesize it in response to ultraviolet (UV) induction. But how quercetin is regulated in vivo is largely unknown, but this compound is important by itself or in combination with other molecules for medicinal use. Pirins are highly conserved proteins and identified as possessing endogenous quercetinase, (i.e. Pirin) can cleave quercetin, where the product is not as effective an antioxidant as quercetin. Hence, an overactive Pirin can be destructive to plant tissues where quercetins may be an important component of protection for the plant, and for use by humans. We investigated the impact of PRN1 on quercetin metabolism as well as seedling establishment in Arabidopsis thaliana, to better understand applications of our technology to herbs and other plants of medicinal importance. We have made a number of transgenics that test the functions of Pirin protein and the effects on natural plant flavonoids. Human Pirin can regulate some of the medicinal ingredients from plants. Hence we investigated how quercetins might be produced in the plants in response to human Pirin, so we can understand the derived medicinal properties. Assays developed revealed the differences between plant and human Pirin, and the differences in how quercetins and other flavonoids can be synthesized. We will also demonstrate how UV technology can benefit improvement to medicinal properties of the plants that are already utilized in mammalian diets.

Specified Source(s) of Funding: NSF-MCB & POC AWARD UIC

11:45–12:00 PM

Medicinal Plants for Skin Disorders

Namrita Lall*
University of Pretoria, Pretoria, South Africa

Bioassay-guided fractionation of the shoots of a medicinal plant belonging to Myrsinaceae led to the isolation of a new compound, ‘Myricetin-3-O-(2”,4”-diacetyl)α-L-rhamnopyranoside’, along with 12 known metabolites. This is the first report on the isolation of six compounds from the shoots of the plant. The compounds’ structures were elucidated by different spectroscopic methods including 1D, 2D NMR experiments and HR-ESI-MS analysis. In order to identify natural tyrosinase inhibitors and antioxidant agents, these isolated compounds were evaluated for their anti-tyrosinase and antioxidant activities. All the compounds exhibited good tyrosinase inhibitions, whereas, compounds 4, 10, 11, and 12 showed excellent anti-tyrosinase activities with 50% inhibitory concentrations (IC50) values ranging from 43.90, 24.94, 35.00, and 26.20 μg/mL, respectively. The anti-tyrosinase activity of myrisinoside A, myrisinoside B, myricetin, mearnsitrin, myricetin 3-O-(4”-O-acetyl)-rhamnopyranoside and quercetin 3-(3”,4”-diacetyl-rhamnoside) have been reported for the first time. Compounds 1-12 also displayed excellent antioxidant activities with IC50 values ranging from 0.92–1.85 μg/mL. This is the first report on the DPPH radical scavenging activity of myrisinoside A, myrisinoside B, mearnsitrin 3-O-(4”-O-acetyl)-rhamnopyranoside, myricetin 3-O-(4”-O-acetyl) rhamnopyranoside and quercetin 3-(3”,4”-diacetyl-�hamnoside). The effects of plant on the expression of the tyrosinase gene and on melanin transfer were also evaluated. It was concluded that the inhibition of melanin by the plant was post-transcriptional. The mechanism of action of the extract was further substantiated by in the melanin transfer assay where melanosomes containing melanin were not found to be transferred between the melanocytes and keratinocytes, indicating inhibition at a possible protein level.

Specified Source(s) of Funding: National Research Foundation of South Africa

12:00–12:15 PM

Analysis of Serum Marker Proteins in Hepatitis C Patients As Affected By Neem (Azadiracta indica)

Fouzia Tabassum*
University of the Punjab, Lahore, Pakistan

Nasir Mahmood
University of Health Sciences, Lahore., Pakistan

Basharat Ali
University of Health Sciences, Lahore, Pakistan

Fifty patients infected with hepatitis C virus were subjected to serum proteins analysis which was inhibited by Azadirecta indica extracts in comparison with normal control subjects in order to determine specific marker proteins in blood serum. In serum of HCV patients increased values of alanine transaminase, alkaline phosphatase, bilirubin, total protein, calcium, potassium and sodium were observed as compare to healthy individuals. However, serum albumin was not much fluctuated. Electrophoresis of serum samples of HCV patients showed that 14 Kda and 30 Kda proteins were expressed at high level while in normal healthy individuals 19 Kda protein was observed predominantly. In serum samples of both HCV and healthy individuals 60 Kda protein was also observed. The serum analysis results were further confirmed on high-pressure liquid chromatography analysis. The proteins expressed in serum of HCV patients may be further validated in different populations. Fifty patients infected with hepatitis C virus were subjected to serum proteins analysis which was inhibited by Azadiracta indica extracts in comparison with normal control subjects in order to determine specific marker proteins in blood serum. In serum of HCV patients increased values of alanine transaminase, alkaline phosphatase, bilirubin, total protein, calcium, potassium and sodium were observed as compare to healthy individuals. However, serum albumin was not much fluctuated. Electrophoresis of serum samples of HCV patients showed that 14 Kda and 30 Kda proteins were expressed at high level while in normal healthy individuals 19 Kda protein was observed predominantly. In serum samples of both HCV and healthy individuals 60 Kda protein was also observed. The serum analysis results were further confirmed on high-pressure
QTL Mapping of Flowering and Branching Traits in Petunia

Qixia Chen*
Michigan State University, East Lansing, MI
Ryan M. Warner
Michigan State University, East Lansing, MI
Yufang Guo
Michigan State University, East Lansing, MI

The flowering intensity of individual plants is determined by the number of flower buds per branch along with the number of branches. Understanding the genetic control of traits contributing to overall flowering intensity could aid in breeding more floriferous cultivars. The objective of the study was to perform quantitative trait locus (QTL) mapping analysis with multi-year phenotypic data from an interspecific Petunia axillaris x P. exserta F1, recombinant inbred line (RIL) population. Total flower bud number, flower buds on the primary stem, total branch number and number of branches with flowers were evaluated for two seasons on 171 RILs and the parental species at 14°C, 17 °C, and 20 °C under a 16-hour photoperiod. A high-density single nucleotide polymorphism-based genetic linkage map for this population was generated using genotyping-by-sequencing. From 7 linkage groups, 6,291 SNP markers were combined into 363 bins. The bins were used to build a bin-based linkage map spanning a total of 377 cM with an average bin distance of 1.04 cM. Results from the analysis of the first season’s data identified 12 QTL at 14 °C, 12 QTL at 17 °C, and 13 QTL at 20 °C for the four flowering and branching traits. Two QTL explained 26.4% and 34.2% of the phenotypic variation for total flower bud number and total branch number in linkage group 2 and 3, respectively, at 14°C. Five QTL on linkage group 4 explained 25.7% to 36.5% of the variance for total flower bud number, flower buds on the primary stem, and total branch number at 20 °C. These results will be validated using the second season’s data. Results from both analyses will be used for identifying candidate genes associated with traits contributing to flowering intensity.

Specified Source(s) of Funding: USDA– Specialty Crop Research Initiative; USDA– Floriculture and Nursery Research Initiative; Michigan State University, East Lansing, MI

Protoplast Viability in the Lilacs and Prospects for Cell Manipulation

Nathan Maren*
North Dakota State University, Fargo, ND
Todd West
North Dakota State University, Fargo, ND

Black spot disease [Diplocarpon rosae (Lib.) Wolf] of rose is the most important leaf disease of garden roses in warm humid areas. Although the partial (horizontal) resistance to black spot has been shown to be moderately heritable, the responsible quantitative trait loci (QTL) remain unidentified. Because of the interspecific nature and high heterozygosity in commercial roses the genetic information available on rose is limited. To effectively identify markers associated with the QTL controlling black spot resistance, one needs abundant markers along the genome and careful phenotyping. The objective of this study is to utilize genotyping by sequencing technology to generate thousands of informative single nucleotide polymorphism (SNP) markers for genetic linkage and QTL mapping. Thus far rose seedlings and parents have been phenotyped for partial black spot resistance in the lab and the field, and an efficient protocol to extract high quality DNA for sequencing from rose leaves has been developed. Fifteen diploid rose populations created from the crosses of black spot resistant breeding lines derived from R. wichuriana ‘Basye’s Thornless’ with susceptible commercial cultivars (‘Vineyard Song’, ‘Red Fairy’, ‘Sweet Chariot’, and ‘Little Chief’) were used for SNP detection. Their genomic DNA was digested using a methylation sensitive enzyme and the resulting fragments were sequenced using the Illumina Hiseq2500 platform. The sequencing reads were aligned to the strawberry V1.1 genome since the genomic sequence of rose is not yet available. The identified SNP markers were utilized to create individual genetic maps of each population and SNPs common to each population along with SSR (simple sequence repeat) markers were used to construct a diploid consensus map and identify markers associated with partial black spot resistance trait.

Specified Source(s) of Funding: RosBreed II; China Scholarship Council

Map Construction and Black Spot Resistance QTL Detection in Diploid Rose

Muqing Yan*
Texas A&M University, College Station, TX
David Byrne
Texas A&M University, College Station, TX
Patricia Klein
Texas A&M University, College Station, TX
Qianni Dong
Texas A&M University, College Station, TX

Black spot disease [Diplocarpon rosae (Lib.) Wolf] of rose is the most important leaf disease of garden roses in warm humid areas. Although the partial (horizontal) resistance to black spot has been shown to be moderately heritable, the responsible quantitative trait loci (QTL) remain unidentified. Because of the interspecific nature and high heterozygosity in commercial roses the genetic information available on rose is limited. To effectively identify markers associated with the QTL controlling black spot resistance, one needs abundant markers along the genome and careful phenotyping. The objective of this study is to utilize genotyping by sequencing technology to generate thousands of informative single nucleotide polymorphism (SNP) markers for genetic linkage and QTL mapping. Thus far rose seedlings and parents have been phenotyped for partial black spot resistance in the lab and the field, and an efficient protocol to extract high quality DNA for sequencing from rose leaves has been developed. Fifteen diploid rose populations created from the crosses of black spot resistant breeding lines derived from R. wichuriana ‘Basye’s Thornless’ with susceptible commercial cultivars (‘Vineyard Song’, ‘Red Fairy’, ‘Sweet Chariot’, and ‘Little Chief’) were used for SNP detection. Their genomic DNA was digested using a methylation sensitive enzyme and the resulting fragments were sequenced using the Illumina Hiseq2500 platform. The sequencing reads were aligned to the strawberry V1.1 genome since the genomic sequence of rose is not yet available. The identified SNP markers were utilized to create individual genetic maps of each population and SNPs common to each population along with SSR (simple sequence repeat) markers were used to construct a diploid consensus map and identify markers associated with partial black spot resistance trait.

Specified Source(s) of Funding: RosBreed II; China Scholarship Council
Few other woody plants embody the preeminence of temperate woody plants in garden cultivation like the lilacs. In spite of their relationship, the trees lack the diversity of cultivated floral forms observed within the shrub lineages. Typical selection and cross-pollination schemes within the tree lilacs have revealed few inherent variations for flower color throughout the long history of cultivation. Interspecies crosses have repeatedly failed between the two groups. Somatic hybridization is an in vitro technique in plant improvement that has demonstrated the ability to overcome the barriers of sexual incompatibility across species and familial divides. With *Citrus* spp. somatic fusion as a guideline for *Syringa* spp. protoplast isolation and culture, experiments were designed to optimize the conditions for somatic fusion. Protoplast isolation experiments examined various enzyme concentrations, formulations, and durations of exposure on protoplast liberation and viability. Leaf tissues from in vitro grown plants representing the taxonomic Subgenus *Syringa* series *Syringa* (*Syringa xchinensis*) and series *Villosae* (*Syringa x ‘Dancing Druid’*) were used as source material for those experiments. Digestion solutions were assessed for viability with fluorescein diacetate (FDA). Protoplast isolation experiments revealed significant increases in protoplast yield with the use of Driselase® from *Basidiomycetes* sp. (*P > 0.01*) for any duration of exposure. Treatments containing pectinase and hemicellulase extracts from *Rhizopus* sp. (*Macerozyme R-10*) had a dramatic increase in protoplast yield over those treatments only containing hemicellulases derived from *Aspergillus niger* (*P > 0.01*). Protoplast isolation increased with increasing exposure to most digestion solutions, but came with an increased incidence of cell lysis or spontaneous fusion. Early indications envisage a difference in protoplast viability based on leaf anatomy. These differences may provide a convenient means for flow assisted cell sorting into groups that are more or less fit for regeneration and/or other techniques in plant protoplast manipulation.

12:00–12:15 PM  
**Tetraploid Induction of *Hibiscus moscheutos* in Tissue Culture**  
Zhitong Li*  
University of Georgia, Athens, GA  
John Ruter  
University of Georgia, Athens, GA

*Hibiscus moscheutos* (*2n = 2x = 38*) is a perennial plant native to wetland areas in the eastern United States. Commercial breeding has focused on compact stature and enhanced floral characteristics. In recent years, interest has arisen to breed for purple foliage and sterility. A purple-foliage selection (Hib14-113) was treated using colchicine and oryzalin as mitotic inhibitors to induce tetraploid breeding lines to be used for developing triploid genotypes. Hib14-113 plants were first transferred into tissue culture growing in MS basal media. After plants were well established in tissue culture, 10 two-node shoots per treatment were immersed in 0%, 0.025%, 0.05%, 0.1% (w/v) colchicine for 12, 24, 36 hours, and 0 μM, 100 μM, 125 μM, 150 μM oryzalin solutions for 3-, 6-, 9-hour durations on a rotational shaker (120 rpm). Following treatment the shoots were thoroughly rinsed with water and transferred back to MS basal media. Plants from each chemical treatment (*n = 24*) were placed under a 16-hour photoperiod and were arranged using a randomized complete block design with ten blocks. Survival of treated shoots was assessed six weeks after treatment. The ploidy level of plants was examined via flow cytometry. Following root establishment, plants were gradually acclimated to a greenhouse environment for evaluation of ornamental characteristics. After plants were determined to be diploid, mixaploid or tetraploid, they were all evaluated based on plant height, size, and other characteristics related to flowers, leaves and production of seeds. The concentration of colchicine (*P < 0.001*) had an effect on survival of shoots. Colchicine had a higher lethal effect on the plants with 56.7% rate of survival, compared to 81.7% survival of oryzalin-treated plants. Both colchicine and oryzalin are considered effective polyploidy-inducing agents for *Hibiscus moscheutos*, and results on ploidy levels will be reported.

**Specified Source(s) of Funding:** Institute of Plant Breeding, Genetics and Genomics, University of Georgia

12:15–12:30 PM  
**Collecting Horticulturally-useful Traits In the Wild: Methodology to Maximize Genetic Gain and Minimize Risk**  
Neil Anderson*  
University of Minnesota, St. Paul, MN

The potential value to be found in collecting wild species of ornamental crop relatives is immensely proportional to the careful planning of collection trips, integration of local experts, serendipity in finding mutant genotypes, and risk management both during collection and thereafter in the breeding, domestication and selection process. Objectives of this research were to demonstrate the value of well-planned collecting trips to maximize genetic gain in future breeding and minimize risks in collected plant materials. More than 30 years of plant collecting experience throughout the world (S. Africa, Europe, N. America) and testing these findings with undergraduate students in a plant production course for new crop development are the basis for this research. Essential collection procedures include creating a crop ideotype to identify which traits are of importance in the new germplasm; these traits will direct the timing of when to collect, the best location of populations to maximize trait expression in wild populations, and existence of natural hybrids, rather than collecting only when seed are produced and implementing targeted (centers of origin, diversity) vs. random collections. Methods of population sampling to maximize genetic diversity, the numbers of genotypes to collect, and minimizing invasion risk also influence potential genetic gain.

An asterisk (*) following a name indicates the presenting author.
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**Correlation of Seed Germination and Flowering Order in Pyrethrum Seedling Populations**

Neil Anderson*
University of Minnesota, St Paul, MN
Robert A. Suranyi
McLaughlin Gormley King Company, Minneapolis, MN
Steven M. Gullickson
McLaughlin Gormley King Company, Minneapolis, MN

Selection for correlative early seed germination and flowering in first year seedlings is challenging for producers. The objective of this study was to analyze pyrethrum populations for differential trait expression to determine whether selection could enhance correlative expression of these traits. Seven populations of commercial and wild seed were grown from sowing to flowering in year 1; seedlings were selected in the plug production phase for early germination (Germ Wks. 1–3; G1–G3). Stem height, inflorescence height, number of vegetative shoots, number of flowering shoots, number of ray petals/flower, flower diameter, disc diameter, mean petal length, visible bud date (VBD), and flowering were tracked. Seed germination week was significant for VBD and flowering dates for all seed lots and is an important trait to use for selecting early flowering plants. On average, it took 34–39 weeks to reach VBD and an additional 3–4 weeks to flower. Stem and inflorescence height had only slight variation. Two seed lots had significantly lower number of ray petals/flower (14.59–16.41) than the highest (20.55). Seed producers could select the earliest germinating seedlings (G1–G3) to enhance early flowering in field production the first year.

**Specified Source(s) of Funding:** McLaughlin Gormley King Company

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**Oral Presentations**

12:30–12:45 PM

**Correlation of Seed Germination and Flowering Order in Pyrethrum Seedling Populations**

Erik Draper
Ohio State University Extension, Burton, OH

Ohio Master Gardener Volunteers (MGVs) are involved in diagnosing cultural, disease and pest problems of plants for Ohio residents and continually seek training to improve their diagnostic skills. OSU Extension Educators developed an OSU Extension FactSheet PP401.03 entitled, “20 Questions on Plant Diagnosis” to be used as a tool that can lead to improved plant diagnostic abilities. The 20 questions follow a logical order and provide the necessary steps that one must take in order to make an accurate diagnosis. Beginning with identifying the plant and the common problems of the plant and ending with recommendations, the questions provide the MGVs with a valuable tool to guide them through the diagnostic process. This tool is utilized in Diagnostic Workshops and various programs for MGVs in order to provide consistent content when it comes to learning how to diagnose plant problems. Rather than learning about a specific problem, learners look at the process that will lead to greater success in diagnostics. The 20 questions guide learners through the process of developing a sound diagnosis. Approximately 360 MGVs have participated in training in the past three years utilizing this tool; all indicated an increase in self-confidence as a result of the training. In addition, this tool has been presented to professional green industry organizations in Ohio as well as nationally at the International Society of Arboriculture Conference (2015, 2016).

3:45– 4:00 PM

**Use of Audio Podcasts As a Catalyst for Extending the Reach of Extension Master Gardener Volunteer Urban Horticulture Programs**

Lucy Bradley*
North Carolina State University, Raleigh, NC

Extension Master Gardener Volunteers in Durham County, NC, created a radio show to distribute expert information and feature timely content on sustainable gardening. The show has been featured on five radio stations across the state and is available as a podcast via the website. Twitter, Facebook and a North Carolina State Extension portal are used to promote the podcasts. Extension Master Gardener Volunteers serve as producers, anchors, reporters, and transcribers for the show. In its second year, the impact of the show has spread throughout the entire volunteer program. Experts are interviewed for the podcast, then podcast topics are used for newsletter articles and speaker’s bureau...
The Kentucky Extension Master Gardener Program (KEMGP) began in the late 1980’s and was initially active in a few urban counties. Today the program is active in 42 Kentucky counties (35% of all counties) and averages over 1400 active volunteers each year who contribute in excess of 42,000 volunteer service hours and provide research-based horticultural information to over 82,000 direct contacts with Kentucky citizens. The KEMGP volunteers play vital roles in addressing local Extension clientele lawn and garden issues by phone and/or at Extension offices, assist with teaching horticulture to beginning gardeners, and help clients explore environmental options. This study sought to determine how long KEMG volunteered for the program and their motivations for volunteering. A survey instrument was adapted with permission from Clary and Snyder’s Volunteer Functions Inventory to measure the KEMGP volunteer motivations. The instrument consisted of 50 questions that measured various motivational functions for volunteering and 14 questions pertaining to their level of volunteer service, initial/continuing subject matter preferences with the KEMGP training, and demographics. Surveys were distributed to 675 volunteers with a 44% response rate. The respondents were mostly female (82%), Caucasian (96%), married (75%), and age 56–70 or older (83%), with 56% of the respondents retired. Thirty-five percent of the respondents had been a KEMGP volunteer for one to two years while 19% had been a KEMGP volunteer for nine or more years. Ninety-four percent of the respondents had been a KEMGP volunteer for one to two years while 19% had been a KEMGP volunteer for nine or more years. Ninety-four percent of the respondents stated they are presently volunteering with the KEMGP was related to the Values Function (to gain career-related information) with a mean of 1.75. Results indicated KEMGP volunteers mostly choose to volunteer with KEMGP because they value helping people through the program and believe in the mission of the KEMGP. These data will be useful for county MG coordinators to understand why new individuals may wish to participate in the KEMGP and what factors are most important in training and retention.

4:00–4:15 PM

Uncovering the Motivations of Kentucky Extension Master Gardener Program Volunteers

Richard Durham*
University of Kentucky, Lexington, KY

Tanya C. Franke-Dvorak
University of Kentucky, Lexington, KY

The Kentucky Extension Master Gardener Program (KEMGP) began in the late 1980’s and was initially active in a few urban counties. Today the program is active in 42 Kentucky counties (35% of all counties) and averages over 1400 active volunteers each year who contribute in excess of 42,000 volunteer service hours and provide research-based horticultural information to over 82,000 direct contacts with Kentucky citizens. The KEMGP volunteers play vital roles in addressing local Extension clientele lawn and garden issues by phone and/or at Extension offices, assist with teaching horticulture to beginning gardeners, and help clients explore environmental options. This study sought to determine how long KEMG volunteered for the program and their motivations for volunteering. A survey instrument was adapted with permission from Clary and Snyder’s Volunteer Functions Inventory to measure the KEMGP volunteer motivations. The instrument consisted of 50 questions that measured various motivational functions for volunteering and 14 questions pertaining to their level of volunteer service, initial/continuing subject matter preferences with the KEMGP training, and demographics. Surveys were distributed to 675 volunteers with a 44% response rate. The respondents were mostly female (82%), Caucasian (96%), married (75%), and age 56–70 or older (83%), with 56% of the respondents retired. Thirty-five percent of the respondents had been a KEMGP volunteer for one to two years while 19% had been a KEMGP volunteer for nine or more years. Ninety-four percent of the respondents stated they are presently volunteering with the KEMGP was related to the Values Function (to gain career-related information) with a mean of 1.75. Results indicated KEMGP volunteers mostly choose to volunteer with KEMGP because they value helping people through the program and believe in the mission of the KEMGP. These data will be useful for county MG coordinators to understand why new individuals may wish to participate in the KEMGP and what factors are most important in training and retention.

4:15–4:30 PM

A Review of Extension Master Gardener Program Recordkeeping Systems

Sheri Dorn*
University of Georgia, Griffin, GA

Recordkeeping systems (or volunteer management systems) are capacity-building tools for Extension Master Gardener Volunteer (EMGV) programs. States have been using electronic systems for as many as 24 years. Early systems demonstrated the ability to establish program accountability while also reducing the administrative burden of managing volunteers. A survey was conducted in June 2015 to document and compare recordkeeping systems for EMGV programs nationally. There were twenty-nine responses from 24 states, with 20 states reporting use of recordkeeping systems. Differences in the systems were reported, including costs for development and maintenance, system purposed, and system functions. Respondents estimate that 73% of EMGVs regularly and consistently self-report via online recordkeeping systems. More than half of respondents (58%) indicate that EMGVs are receptive to using online database systems for other functions, with an additional 33% of respondents indicating the possibility. This bears significance as states and national committees work to develop impact evaluation models for EMGV programming.

4:30–4:45 PM

First Year Impact of Extension Floral Design Program

James DellPrince*
Mississippi State University Coastal Research and Extension Center, Biloxi, MS

In July 2015, Mississippi State University began a new program in horticulture extension; floral design. Multilateral programs were developed with appeal to amateurs, professional florists and producers. Survey instrumentation sought to find if participants increased floral design knowledge, learned new skills related to floral design and potential use of new knowledge/skills. Programs were initiated to accommodate learning needs for three distinct groups. Amateur designers were accommodated in the Floral Enthusiast category. Monthly workshops were structured with demonstrations highlighting design features, post-design care and handling, followed by hands-on learning and individualized critiques. Most participants reported an interest in a certification,
similar in scope to the Master Gardener program. Professional florists have needs in keeping up with technical advances in a changing industry. Outcomes of a focus group meeting found florists had difficulty finding time to practice new styles and techniques. The floral studio at Coastal provided a place for trial and error practice. Participants reported positive results when creating designs practiced in the workshops, including decreased labor and sales process confidence. Participants were encouraged to post finished work immediately upon project completion to social media platforms. One florist received an order minutes after posting while another attributed $700 in retail sales using new techniques. A 90-minute lecture/demonstration titled Beautiful Things From Mississippi was delivered at four MSU Research and Extension Centers, main campus, and numerous farmers markets and meetings throughout the state. Participants in this program reported an increase in sales after interaction with extension. Mississippi State University Extension was able to help one producer increase visibility by featuring his products in demonstrations and Facebook shares. A cut flower grower with limited market area developed cut-willow variety pack as a foray for shipping.

4:45–5:00 PM

**Consumer Preferences of Seven Indigo Purple Tomato Varieties Grown in Kentucky**

Srijana Thapa Magar*
Kentucky State University, Frankfort, KY

Kirk Pomper
Kentucky State University, Frankfort, KY

Jeremiah Lowe
Kentucky State University, Frankfort, KY

Sheri Crabtree
Kentucky State University, Frankfort, KY

Oregon State University released the Indigo series of tomatoes in 2012, however consumer’s preference of Indigo series over heirloom tomatoes has not been evaluated in Kentucky. The objective of this study was to compare the Indigo series of tomatoes to heirloom tomatoes in terms of flavor, texture, and appearance in Kentucky. The varieties Indigo Apple, Indigo Blue Beauty, Indigo Blueberries, Indigo Kumquat, Indigo Rose, Indigo Ruby, and Indigo Cherry Drops tomatoes, along with Koralik were evaluated for flavor, texture, and appearance by consumers through a taste test on campus as well as at a Kentucky State University (KSU) Third Thursday event. The tomatoes were sorted, cleaned, cut and placed on plates to serve. Whole fruit of each variety were also displayed side by side for consumers to judge their appearance. Both tasting events were blind taste tests where each tomato variety was placed consecutively with a random number on the plate. The consumers were then asked to rate the fruit based on their appearance, flavor and texture. The survey data were collected and analyzed. I. Cherry was significantly preferable to I. Blue Beauty, I. Blueberries and I. Rose in terms of flavor at the campus test. However, Koralik and I. Ruby were preferable to I. Apple in terms of appearance at the KSU Third Thursday event. There were no significant differences in terms of texture in any tomatoes. Moreover, the Indigo series of tomatoes were preferable to Koralik on the basis of flavor.

5:00–5:15 PM

**Awareness, Support and Perceived Impact of the Connecticut Pesticide Bans**

Julie Campbell*
University of Connecticut, Storrs, CT

Victoria Wallace
University of Connecticut, Storrs, CT

Ben Campbell
University of Georgia, Athens, GA

Connecticut, as with a couple of other states, have enacted new laws in an attempt to limit pesticide exposure to children. In Connecticut these laws have been primarily focused toward schools and municipal maintained areas. A central tenant of these laws is that limiting exposure will have increased health consequences. However, even though policies are being enacted, little research exists that examine how residents perceive these laws. Using results from an online survey of around 500 consumers within Connecticut, we examine Connecticut resident perceptions of these laws as well as examine how residents view the risks associated with pesticide (and other lawn maintenance product) applications within schools, parks, athletic fields, and at their homes. More specifically, we measure awareness and support for the Connecticut pesticide laws that ban pesticides being applied on K–8th grade school grounds and at municipal areas. We then examine resident views associated with the impacts of the laws, such as impact on child health, school ground budgets, field quality, etc. With respect to areas not covered by the pesticide bans, such as homes, we examine whether residents have changed their maintenance practices since the pesticide bans have come into effect. Finally, we examine the role of demographics on support for/against the pesticide bans as well as the role of demographics on valuing their impact. Notably, we find that demographics do play a role in both awareness and perceived impact of the pesticide bans. Potential policy implications are discussed.

**Oral Session—Floriculture 2**

Moderator: Nicholas J. Flax
Iowa State University, Ames, IA

4:00–4:15 PM

**Commercial Greenhouse Producers Can Produce High-Quality Annual Bedding Plants in Biopolymer-based Biocontainers and Are Willing to Use Them**

Nicholas J. Flax*
Iowa State University, Ames, IA
Reducing the use of conventional plastics by employing biopolymer-based biocontainers in containerized greenhouse crop production of ornamental plants could improve the sustainability of commercial greenhouse crop production. Our objectives were to quantify the growth and quality of herbaceous annuals grown in different biopolymer-based biocontainers in commercial greenhouses and quantify interest and willingness to use biocontainers in their commercial production systems. Seedlings of ‘Serena White’ angelonia (Angelonia angustifolia Bentham) and ‘Maverick Red’ geranium (Pelargonium xhortorum L.H. Bailey) and nine different container types were taken to six commercial greenhouses in the upper Midwest. This study utilized eight different types of biocontainers and a control: 1) 80% polylactic acid (PLA) and 20% Biore™ (BR); 2) 90% PLA and 10% lignin; 3) 50% PLA, 30% soy protein polymer (soy), and 20% BR; 4) 60% PLA and 40% soy; 5) 80% polyhydroxyalkanoates (PHA) and 20% dried distiller’s grains (DDGS); 6) 55% PLA, 35% soy, and 10% BR; 7) recycled PLA; 8) biopolyurethane-coated paper fiber; and 9) petroleum plastic (control). Plants were grown alongside other bedding annuals in each of the commercial greenhouses, and producers employed their standard crop culture practices. Data were collected to characterize growth when the majority of plants were flowering, while questionnaires to quantify producer perceptions and willingness to use, interest in different container attributes, and satisfaction were administered at different times during the experiment. Container type interacted with greenhouse to affect angelonia Growth Index (GI) and shoot dry mass (SDM), as well as shoot, root, and container ratings. For example, GI of angelonia grown in PLA/BR (80/20) containers at greenhouse B were 22% smaller than plants at greenhouse A. Alternatively, GI were similar (18.4–20.6) across all container types within greenhouse A. Container type and greenhouse did not interact to affect geranium GI or shoot rating, but did for SDM, and root and container ratings. Geranium SDM was similar (4.54–5.68 g) across container types at greenhouse E, while SDM of geranium grown in PHA/DDGS across greenhouses varied from 2.85–8.97 g. Root ratings for geranium grown at greenhouse G were similar except for container types that incorporated soy, compared to greenhouse C where plants in all container types except PLA/soy/BR (50/30/20) were similar. These results indicate that commercial producers can grow herbaceous annuals in wide range of biopolymer-based biocontainers with few or no changes to crop their culture practices.
ers using paclobutrazol drenches varies by type of biocontainer being used. Producers should reduce paclobutrazol drench concentrations to produce appropriately-sized plants if substituting coir or peat biocontainers for traditional petroleum plastics.

4:30–4:45 PM

**The Impact of Deficit Irrigation on the Postharvest Vase Life of Cut Delphinium ‘Guardian Blue’ Flowers**

Leslie K. Peck*
Virginia Polytechnic Institute & State University, Blacksburg, VA

Jim Owen
Virginia Polytechnic Institute & State University, Virginia Beach, VA

Joyce Latimer
Virginia Polytechnic Institute & State University, Blacksburg, VA

Holly Scoggins
Virginia Polytechnic Institute & State University, Blacksburg, VA

Minimizing postharvest water loss through stomata may delay wilting or senescence in cut flowers. Drought stress induces stomatal closure and decreased transpiration rates as plants try to minimize water loss. Subjecting cut flowers to drought stress during production may also limit postharvest water loss, thus extending vase life. The objective of this study was to investigate the postharvest impacts of drought stress on delphinium (Delphinium elatum L.) ‘Guardian Blue’ cut flowers. Delphinium ‘Guardian Blue’ plants were grown in soilless media in a greenhouse. After flower bud initiation, delphinium plants received sufficient irrigation (control), moderate or severe water deficits. Deficit irrigation was applied by measuring the volumetric water content (VWC) of the substrate once daily. Mean daily VWC for the control, moderate deficit, and severe deficit treatments were 20.0 ± 0.4%, 18.2 ± 0.4%, and 14.5 ± 0.5%, respectively. Moderate or severe water deficits did not change pre- or postharvest stomatal conductance or transpiration of delphinium ‘Guardian Blue’ cut flowers. Deficit irrigation did not extend vase life of delphinium ‘Guardian Blue.’ Growers may be able to reduce water use during production of delphinium ‘Guardian Blue’ cut flowers without adversely impacting postharvest longevity.

*Specified Source(s) of Funding:* The Association of Specialty Cut Flower Growers

4:45–5:00 PM

**Evaluating Calibrachoa (Calibrachoa xhybrida Cerv.) Variety Sensitivity to Iron Deficiency at High-substrate pH**

Ryan Dickson*
University of Florida IFAS, Gainesville, FL

Paul Fisher
University of Florida, Gainesville, FL

Floriculture crop species that are inefficient at iron uptake are susceptible to developing iron deficiency symptoms in container production at high-substrate pH. The objective of this study was to compare varieties of iron-inefficient calibrachoa (Calibrachoa xhybrida Cerv.) in terms of their susceptibility to showing iron deficiency symptoms when grown at high- vs. low-substrate pH. In a greenhouse factorial experiment, 24 varieties of calibrachoa were grown in peat:perlite substrate at low pH (5.4) and high pH (7.1). Shoot dry mass, leaf SPAD chlorophyll index, flower index value, and shoot iron concentration were measured after 13 weeks at each substrate pH level. Of the 24 varieties, ANOVA found that 19 varieties had lower SPAD and 18 varieties had reduced shoot dry mass at high substrate-pH compared with values at low-substrate pH. High-substrate pH had less effect on flower index and shoot iron concentration than its effect on SPAD or shoot dry mass. No visual symptoms of iron deficiency were observed at low substrate-pH. Varieties were separated into three groups using k-means cluster analysis, based on the four measured variables (SPAD, dry mass, flower index, and iron concentration). These four variables were each expressed as the percentage of reduction in measured responses at high- vs. low-substrate pH. Greater percent reduction values indicated increased susceptibility of varieties to high-substrate pH. The three clusters, which approximately represented high, medium, or low sensitivity to high-substrate pH, averaged 59.7%, 42.8%, and 25.2% reduction in SPAD, 47.7%, 51.0%, and 39.5% reduction in shoot dry mass, and 32.2%, 9.2%, and 27.7% reduction in shoot tissue iron, respectively. Flowering was not different between clusters when tested with ANOVA. The least pH sensitive cluster included all four varieties in the breeding series ‘Calipetite’, which had low shoot dry mass at low-substrate pH, indicating low overall vigor. There were no differences between clusters in terms of their effect on substrate pH, which is one potential plant response to affect iron availability. This experiment demonstrated an experimental and statistical approach for plant breeders to test sensitivity to substrate pH for iron-inefficient floriculture species.

5:00–5:15 PM

**Exponential Growth of Gladiolus ‘Glamini’ Under the Influence of Plant Growth Regulators**

Jaser Aljaser*
University of Minnesota, St. Paul, MN

Neil Anderson
University of Minnesota, St. Paul, MN

Gladiolus xhybridas is a perennial monocot in the Iridaceae. Gladiolus is top ten major cut flowers sold in the United States. In commercial production, gladioli corms produce 1–2 inflorescences per shoot, each of which produce multiple flowers. However, gladioli have the ability to generate multiple shoots, which could influence the flowering timing and floral traits of gladiolus in addition to cormel production. Our objectives are to analyze the influence of plant growth regulators (gibberelic acid 3, GA3; 6-benzyadenin, and BA) on the number of shoots,
number of inflorescences/shoot, flower timing, plant and flower height, weight and number of corms and cormels produced. BA treatments significantly increased the generation of multiple shoots (vegetative, floral): 6.0 vs. 1.2 (BA vs. control and GA	extsubscript{3}, respectively). Also in week 7, GA	extsubscript{3} and the control treatments resulted in significantly taller vegetative shoots than BA. However, in week 13 and beyond the BA treatment overcame this foliage height difference. BA treatments utilized the energy in gladiolus corms to enhance the generation of stalks as a tradeoff of foliage height; yet over time the multiple vegetative shoots were able to support the energy demands, resulting in an exponential growth pattern.

Specified Source(s) of Funding: Kuwait University and the MN Agricultural Experiment Station

Oral Session—Plant Nutrient Management 2
Moderator: William Sciarappa
Rutgers University, Freehold, NJ
4:00–4:15 PM

Comparing Soil Health Among Graminaceous Crops with the Solvita CO	extsubscript{2} Release System
William Sciarappa*
Rutgers University, Freehold, NJ

A three year study compared microbial soil populations in six groups of grass crop production—field corn, sweet corn, equine pasture, turf, golf courses and a bio-energy site. All sites had similar sandy loam soils and were located in Monmouth County, NJ, within a 10-mile radius. The Solvita CO	extsubscript{2} aerobic respiration test measured the release of carbon dioxide from the soil in the spring, summer and fall of 2013, 2014, and 2015. Project objectives were to establish a baseline of soil health, compare carbon flux seasonally among various monocot species and estimate potential nitrogen mineralization in order to adjust fertility recommendations downward and determine effectiveness of any future changes in management practices. Soil pH values ranged from 5.1–6.3 and organic matter 1% to 2%. Soil temperatures in this growing zone 7A at a four inch depth ranged from 20 °F to 40 °F in the winter, 55 °F to 64 °F in the spring and 65 °F to 84 °F in the summer and fall. The bio-energy crop, Miscanthus giganteus, had the highest CO	extsubscript{2} burst of 23 ppm over a 24-hour period which was significantly different at \( P > 0.05 \) than the 11 ppm of golf course bentgrass greens, Agrostis stolonifera. Farm soil results for field corn, Zea mays, and sweet corn, Zea mays convar. Saccharata var. rugosa were only slightly higher at 14.0 ppm than the bentgrass growing in an artificial sand mix. Golf course fairways, equine pastures and residential lawns, all with bluegrass mixes, Poa pratensis, were similar the Miscanthus site yet consistently lower at an average of 21 and 22 ppm, respectively. These higher levels of microbial CO	extsubscript{2} respiration can return 20-30 lbs. of naturally produced nitrogen per acre per year. For the lower rates found from sweet corn, field corn, and golf green sites, the potential nitrogen return ranged from 10–15 lb/A/Yr. Cultural practices as well as cultivar types may contribute to these differences among the grass crop groups. The 1/4 inch, low cut greens do not recycle grass clippings and have very high and frequent application rates of insecticides and fungicides. Furthermore, in contrast to the perennial bio-energy and bluegrass-mix crops, annual crops feature deep disking and frequent tillage practices common in this region that can reduce soil structure, organic matter and stability in the soil environment.

4:15–4:30 PM

Evaluating the Consistency of Soil Lab Results Based on Soil Recommendations for a Horticulture Crop
Edward Bush*
LSU AgCenter, Baton Rouge, LA
Mike Breithaupt
LSU AgCenter, Baton Rouge
Sue Chin
LSU AgCenter, Baton Rouge
Lauren Liuzza
LSU AgCenter, Baton Rouge, LA

Soil test results are the basis for fertilization recommendations in most agriculture and horticulture crops. Differences in methodology often result in different data based on standard operating procedures. However, recommendations should be based on crop needs and soil texture. The objective of this project was to determine the variability of soil recommendations from six soil labs on several a horticulture crop. A homogenized soil sample pH, CEC, C/N ratio, N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Mo, and Zn from each site was analyzed by different labs. Differences in fertilizer recommendations varied widely based on the specific element. Soil lime applications varied for some sites by as much as 50%. Nitrogen recommendations were the most consistent for each crop. Phosphorus, K, and lime varied greatly between labs and soil sites. Micronutrients that varied the most included B, Fe, Mn, Mo, and Zn. Farmers often complain about differences in soil results, but this can often be explained by dilution effect or extraction methods. Fertilizer recommendations are typically programmed by a lab or agronomic specialist. Further tests will evaluate more crops and leaf tissue analysis and recommendations.

4:30–4:45 PM

Use of Compost and Limestone to Establishing Substrate pH and the Impact on pH Buffering Capacity
Matthew Taylor*
Longwood Gardens, Kennett Square, PA
Rachel Kreis
Cornell University, Geneva, NY

An asterisk (*) following a name indicates the presenting author.
Peat moss is the primary substrate component used in the greenhouse industry. The inherent pH of peat moss can range from 3.0 to 4.0 and limestone is typically added to raise pH to a suitable range. Compost can also be utilized as a substrate component and has an inherently high pH of 6.0 to 8.0. When using compost as a substrate ingredient, lime rates must be reduced or eliminated. The first objective of this study was to determine the resulting pH of substrates created with varying amounts of limestone and compost. The second was to assess the impact of the various amounts of limestone and compost on pH buffering capacity. The compost was created from a 1:1:1 weight ratio of a mixture green plant material and restaurant food waste: horse manure: wood chips. The first experiment was a factorial design with five compost rates (0, 10, 20, 30, and 40% by volume), four limestone rates (0, 1.2, 2.4, and 3.6 g·L⁻¹ substrate) with five replications. The experiment was conducted three times, each with a different batch of compost. The base substrate consisted of 25% pine bark, 5% calcine clay, 15% vermiculite, 15% perlite with the remaining 40% consisting of peat and/or compost based on the treatments. With 0 lime, initial substrate pH increased from 4.5 to 6.7 as compost rate increased. This trend occurred at all other lime rates, which had pH ranges of 5.2–6.9, 5.6–7.0 and 6.1–7.1 for rates of 1.2, 2.4, and 3.6 g·L⁻¹ substrate, respectively. These data indicate substrate pH increased significantly as either compost or lime rates increased. The second experiment was a factorial design with four compost rates by volume (0, 10, 20, and 30%), the same four limestone rates as experiment one, and five replications. Each substrate treatment was titrated through incubations with six sulfuric acid rates (0, 0.1, 0.2, 0.4, or 0.7 moles of H⁺ per g of dry substrate). Buffering capacity was determined by taking the negative reciprocal of the linear regression slope of pH vs. mM H⁺. Substrates with a similar initial pH had very similar initial buffering capacities regardless of the compost or limestone rate. These results indicate compost can be used to establish growing substrate pH similar to limestone, and this change will have little to no effect pH buffering capacity.

4:45–5:00 PM

Investigating a Composting Management System for Brown Algae (Sargassum fluitans and Sargassum natans)

Tina Waliczek
Texas State University, San Marcos, TX

Kevin Walsh*
Texas State University, San Marcos, TX

Seaweed biomass, typically green algae species, such as kelp, have been used as a fertilizer for plant growth for centuries. The brown algae that becomes beached along the Gulf shores, known as Sargassum, acts the same way to replenish the nutrients required by coastal flora along the Texas coast. In 2011, Sargassum fluitans Børgesen was added to the Global Invasive Species Database, while Sargassum natans Gaillen remains undocumented by the database. Research from Texas State University has shown positive results of Sargassum used as a feedstock in large-scale composting. Even without treatment to remove salt or other possible contaminants, Sargassum can be a simple feedstock in the production of organic soil amendments such as compost. Compost is the natural process of breaking down organic matter into a usable, waste-free product and is increasingly used as a waste management system. This project examines large-scale compost management of Sargassum fluitans and Sargassum natans (brown algae, or Sargassum, collectively) as a method that can be replicated locally near the communities that are burdened by the plant as well as investigates the limits that a compost management system has when using Sargassum as a feed stock to create a marketable byproduct for use in agriculture, horticulture and related markets. Three recipes were used with the Sargassum, pairing it up with other common, and not so common, feedstocks found in the organic waste stream such as fish carcasses, palm leaves, manure and food waste. The compost was managed over a period of 8 weeks until it was cured before final testing. Samples were sent to Pennsylvania State University for compost quality testing where they used the U.S. Compost Council’s Seal of Testing Approval (STA) Program to analyze for various characteristics of the composite samples of the compost, including pH, soluble salt content (dS/m), stability, nutrient content and pathogens. Results of the project will be presented.

5:00–5:15 PM

Effect of Application Rate and Timing of Meat and Bone Meal As an Organic Fertilizer on Growth and Yield of Sweet Corn

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University of Hawaii at Manoa, Honolulu, HI

Amjad A. Ahmad
University of Hawaii at Manoa, Honolulu, HI

Koon-Hui Wang
University of Hawaii at Manoa, Honolulu, HI

Theodore Radovich
University of Hawaii at Manoa, Honolulu, HI

Meat and Bone Meal (MBM) or tankage is a high-nitrogen (N~10%) solid by-product of animal rendering that is locally-produced/available for use as a fertilizer. Local inputs, such as MBM, are key components of sustainable agricultural systems in Hawai‘i and must be properly applied to achieve crop yields and to limit adverse environmental impacts. The objectives of this study were to examine sweet corn growth and yield response to MBM 1) application rate and 2) application timing. Field trials were conducted in Waimanalo, HI arranged in a Split-Plot RCBD with 4 replicates. Each plot was planted with Supersweet #10 corn (Zea mays L.). Treatments included 5 rates of N (0, 112, 224, 336, and 448 kg·ha⁻¹) and 2 timings of application, before planting (Preplant) or half preplant and the remainder one month later (Split). Suction cup lysimeters were installed at 30 and 60 cm depth (within and below the root zone, respectively) to collect soil water. Weekly, leaf chlorophyll was measured with a
SPAD meter and soil water samples were collected and analyzed for nitrate (NO$_3$-N) and ammonium (NH$_4$-N). Rate of MBM, but not timing, had a significant effect on yield, shoot and root biomass, and leaf area. While timing was not significant, nitrates in soil concentrations below the root zone were decreased by nearly 20% for split application compared to preplant application. In conclusion, as expected yield increased with increasing application rate but more importantly, split application reduced potential for ground water pollution without decreasing yield. These findings will help local farmers work toward precision agriculture by improving their nutrient management when using this local resource.

Tuesday, August 9, 2016

**Poster Session—Undergraduate Student 1**

(001) **Paternity Identification in Sweetpotato (Ipomoea batatas) Using DNA Markers**

Caroline Blanchard*
Louisiana State University, Baton Rouge, LA
Kaleb Danos
Louisiana State University, Baton Rouge, LA
Niranjan Baisakh
Louisiana State University, Baton Rouge, LA
Don La Bonte
Louisiana State University, Baton Rouge, LA

Sweetpotato (Ipomoea batatas) breeding programs use open pollinated nurseries to develop new varieties. Knowledge of the male parent is helpful in designing paired crossing nursery so that ideal crossing combinations can be made. We studied a ten-parent insect resistance crossing nursery and resulting progeny with known female parentage. DNA marker profiles were generated using AFLP and SSR marker systems with the intent of identifying potential male parents.

**Specified Source(s) of Funding:** LSU AgCenter

(002) **Survival of Contaminated Water Spray on the Survival of Escherichia coli on Field-grown Tomatoes**

Annette Kenney*
University of Maryland Eastern Shore, Princess Anne, MD
Chanelle White
University of Maryland Eastern Shore, Princess Anne, MD
Lorna Graham
University of Maryland Eastern Shore, Princess Anne, MD
Smith Brett
University of Maryland Eastern Shore, Princess Anne, MD
Felix Buabeng
University of Maryland Eastern Shore, Princess Anne, MD

According to the Centers for Disease Control and Prevention, between 1998 and 2008 fresh produce was responsible for 46% of foodborne illnesses and 23% of food-related deaths in the United States. Among the possible sources of produce contamination, water used for irrigation and agricultural sprays is a prime concern. In this study, the persistence and survival of total coliforms and generic E. coli, on field-grown tomatoes irrigated with contaminated water was evaluated in a randomized complete block experiment (reps = 4, plants/rep = 15). Tomato plants (variety: BHN 602 VFFF Hybrid) at breaker, pink or red-ripe stage were spray-inoculated 10-days before final harvest with non-chlorinated water containing fresh bovine manure to achieve target cell populations of 0, 100, 1000, and 10000 generic E. coli/100 mL. On days 0 (pre- and post-inoculation), 1, 3, 5, 7, and 9, tomatoes (n =1 5, plot) were analyzed for total coliforms and generic E. coli. Populations of total coliforms and generic E. coli ranged from 2.58 to 4.95 and 0 to 3.14 cfu/g, respectively, during the 9-day study. These results show that under the field conditions of this study generic E. coli present in initially detectable and high concentrations in sprays do not survive on tomato fruits exposed for 9 days. Further research is needed to determine the influence of specific environmental factors on E. coli survival on tomato fruits prior to harvest.

(003) **Diversity Analysis and Association Mapping of Fruit Colors in Capsicum annuum**

Joshua Davidson*
West Virginia State University, Institute, WV
Brittany Davenport
West Virginia State University, Institute, WV
Suresh Alaparthi
West Virginia State University, Institute, WV
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West Virginia State University, Institute, WV

An asterisk (*) following a name indicates the presenting author.
Specified Source(s) of Funding: NIFA

(004) Types and Quantities of Carotenoids in Brown and Purple Paprika during Ripening
Yuju Yamada*
Meiji University, Kawasaki, Japan
Kentaro Kohara
Meiji University, Kawasaki, Japan
Hiromitsu Shibata
Meiji University, Kawasaki, Japan
Sanae Kishimoto
NARO Institute of Floricultural Science, Tsukuba, Japan
Masayoshi Nakayama
NARO Institute of Floricultural Science, Tsukuba, Japan
Takashi Ikeda
Meiji University, Kawasaki, Japan

Immature fruits of brown and purple varieties of paprika (Capsicum annuum L.) were brown, dark purple or light purple, but they all turn red when the fruits are fully mature. However, no assessments have been conducted into the types and quantities of carotenoid components in either these fruit varieties or their changes during fruit maturation. Therefore, in this study we analyzed the carotenoid components of ‘Brownie’, ‘Mavras’, and ‘Tequila’ varieties of paprika at different stages of fruit maturation. Plants were grown hydroponically and sample portions were obtained from the middle part of the fruits at 40, 50, 60, and 70 days after anthesis. Then the carotenoid (β-carotene, capsanthin, capsorbin, lutein, and violaxantin) contents of the samples were analyzed by HPLC with a photodiode array detector. The quantities of carotenoids were increased sharply as ripening for these varieties. In the matured brown variety (Brownie) the main carotenoid was capsanthin, whereas in the light (Tequila) and dark purple (Mavras) varieties it was capsorbin. However, in over-matured fruits the quantities of carotenoids decreased in all varieties. Therefore, our findings indicate that the quantity of carotenoids increases during paprika fruit maturation, but that the main carotenoid varies between the different varieties.
Ricardo Hernández  
North Carolina State University, Raleigh, NC

Mark Kroggel  
University of Arizona, Tucson, AZ

Chieri Kubota  
The University of Arizona, Tucson, AZ

Recent advancements in LED technologies have allowed us to better control the light quality that affects the plant morphology without the use of chemical plant growth regulators. Light quality during the day and the end-of-the-day (EOD) influences the physiology and morphology of plants in various ways by changing the phytochrome form. Previous experiments have shown that application of EOD far-red light produced longer hypocotyl lengths in squash. In vegetable grafting, hypocotyl extension is desired before grafting; however, excessive extension during the post-grafting stage is not acceptable as more compact seedlings are desired for transplanting. In the present experiment we looked at how an application of EOD red light affects morphology and growth of squash rootstock ‘Strongtosa’ (Cucurbita maxima x Cucurbita moschata) and ‘Rembrandt’ cucumbers (Cucurbita sativas). The experiment was performed in a greenhouse from 16 June to 29 July 2015, at an average temperature of 24 °C. The planting density was 625 plants/m² for squash and 173 plants/m² for cucumber. During this time the average photoperiod was 14 h. EOD red light was applied during the twilight period and early night period from 6-9 PM. Due to the lower ratio of red to far-red light during the twilight, red light was expected to increase red to far-red light ratio. The red photon flux was 3 mmol·m⁻²·s⁻¹ and had a maximum wavelength peak of 632 nm provided by LEDs (HWHM: 16 nm). The application of EOD red light reduced the average squash hypocotyl length, stem diameter, and dry weight by 0.7 cm (10%), 0.2 cm (6%), and 0.0167 g (13%), respectively, compared with the control without EOD red light treatment. These parameters for cucumber plants were not significantly different from those in the control; presumably due to lower red to far-red light ratio caused by mutual shading as a result of a high planting density relative to their plant size. These results show that the application of EOD red light works but at a limited degree as a suppressor of hypocotyl elongation. This information can be applied in industry practices in order to create a more compact plant.

(007) Evaluation of Ginseng (Panax quinquefolius) Germination and Aeroponic Seedling Growth in Response to Stratification Duration, GA₃, De-coating, and Media

Reese Morris*  
Middle Tennessee State University, Murfreesboro, TN

Nathan Phillips  
Middle Tennessee State University, Murfreesboro, TN

Song Cui  
Middle Tennessee State University, Murfreesboro, TN

Ginseng (Panax quinquefolius) is a well known and commonly used Chinese herb for improved brain functions, pain relieving effects, enhanced immune system and liver function, as well as anti-stress and anti-fatigue effects. In its natural habitat, ginseng grows in heavily shaded forest type locations. However, a great deal of failure has occurred in the process of trying to grow this plant in a production setting. Ginseng can naturally take anywhere between six to twelve years for it to fully mature. Our objective was to evaluate methods to enhance germination rates and uniformity while producing seedlings for aeroponic production. Three hundred warm stratified Ginseng seeds were cold moist stratified for six weeks. Half of the seeds were then soaked in a 0.1% gibberellic acid (GA₃) solution prior to stratification (Pre-strat), while the other half received the same GA₃ soak at the end of the stratification (Post-strat). After 6 weeks, 64% of the Pre-strat seeds, and 76% of the Post-strat seeds exhibited endocarp splitting (smiling). One hundred and fifty (150) smiling seeds of each group were randomly selected and the non-smiling seeds were returned to the stratification environment for an additional 8 weeks. Half of each group (6 week strat) were then de-coated, resulting in 75 seeds of each treatment; Pre-strat with coat, Pre-strat de-coated, Post-strat with coat, and Post-strat de-coated. All 300 seeds were then planted in coarse sand and placed onto an automated mist bench. Seedling emergence was observed over an eight-week period. The seeds that were stratified for an additional 8 weeks were observed for germination after the full 14 week stratification. Eighteen seedlings at the one true leaf stage were randomly assigned to three media treatments and placed in an automated aeroponic system where growth was evaluated over 12 weeks. Seeds treated with GA₃ prior to stratification emerged at significantly higher rates than seeds treated after the 6-week stratification. De-coating yielded no significant difference in germination percentage. Overall, germination was lower in all 6-week stratification treatments compared to seeds stratified for 14 weeks. Eighteen seedlings were selected and assigned to each of three media treatments used in the aeroponic unit. The treatments were 1) peat moss, 2) perlite, and a 3:1:1 (peat moss:perlite) mix. Growth, chlorophyll content, and mortality were observed over 3 months. Seedling growth parameters differed in response to media with the fine peat moss performing significantly worse than the others.

(008) Evaluation of Exotic and Ornamental Sweetpotato Germplasm for New Sources of Sweetpotato Weevil (Cylas formicarius) Resistance

Andrew Barocco*  
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Mark J. Murry  
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The most harmful pest of the sweetpotato Ipomoea batatas L.
(Lam.) is the sweetpotato weevil *Cylas formicarius* (Fabricus). Crop losses due to weevil damage can reach as high as 100%. Even though chemical control measures and traps are available, the discovery and development of cultivars with genetic resistance to weevil damage are a vital part of an effective IPM (Integrated Pest Management) program. From September 2015 to January 2016, storage roots of eighteen different varieties of exotic and or ornamental origin were evaluated for their weevil resistance as compared to a known control, the cultivar ‘Beauregard.’ Each root was measured, and exposed to exactly six adult female weevils in an enclosed cardboard tube for one week. After one week of laying eggs, females were removed. Subsequent adult weevil emergence began exactly 30 days later. Emerging adults were counted for exactly thirty more days and scores were averaged for each cultivar. A vast majority of the exotic and ornamental cultivars were found to have higher weevil resistance than ‘Beauregard’. One exotic cultivar ‘Unduandopa’ was discovered to have over twelve times the resistance of ‘Beauregard’.

### Poster Session—Bioenergy

**(364) Study of Jatropha curcas and Calophyllum inophyllum Oils for Potential Use As Biodiesel Fuel in Guam**

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Oils of Da’ok (*Calophyllum inophyllum*) and Jatropha (*Jatropha curcas*), two landscape plants in Guam, were evaluated as feedstock for their potential biodiesel production. Da’ok fruits were collected from three villages with different soil substrates. Jatropha fruits were collected at an Agricultural Experiment farm. Yield of da’ok oils were not affected by collection sites. Crude oils of da’ok and jatropha were sent to University of Alaska for converting to biodiesel and their chemical analysis. Chemical characteristics of crude oils were examined for: caloric contents (J/g), iodine value, peroxide value, moisture content, saponification value, and acid value. Composition analysis (C16:0, C18:0, C18:1, and C18:2) was also performed for crude oil and biodiesel obtained. The study indicated that both oils were capable of producing high quality biodiesel, although da’ok oil required additional pre-treatment in order to prevent potential problems when being used as a biofuel. Biodiesels derived from nuts of both plants collected in Guam had very similar chemical composition, having nearly 50% methyl ester (C18:1) for jatropha and 40% for da’ok. This indicated that both biodiesels could be used independently or as a blend of two.

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*Jatropha curcas* is native of Mexico and is distributed in the forests of coastal regions. The plants have shown potential for the production of biofuel, and defatted kernel meal of *Jatropha* non-toxic species can also be used as animal feed; because the seed (kernel) is rich in lipids (55% to 58%) and raw protein (31% to 34.5%). *Jatropha cinerea* is another species distributed in wild populations of northwestern Mexico, which can withstand long drought periods and tolerate up to 100 mM of NaCl. It is believed that the latex is useful to cure all kinds of wounds and burns. *J. curcas* and *J. cinerea* are mainly spread by seed and vegetatively by cuttings, in vitro culture, and grafting mention that rootstocks of *J. cinerea* could be used as an alternative to reduce hydric and saline stress of grafted plants *J. curcas*. The search for new renewable alternatives is growing, of which oil is one of the frontrunners. However, to date there are no studies of *J. curcas* in relation to grafted plants on *J. cinerea* rootstock and the oil content in the seeds. The aim of this study was to compare *J. curcas* ungrafted and grafted on rootstock of *J. cinerea* morphologically and their oilseed content. The experiment was performed in the Laboratory of Plant Biotechnology at CIBNOR, La Paz, Baja California Sur, Mexico. Two-month ungrafted and grafted seedlings were transferred to 5-L pots with Sogemix® substrate and perlite (75% and 25%, V/V, respectively) and planted subsequently in an experimental field. The observations started 3 months after grafting, using 4 ungrafted and 4 grafted plants. The parameters observed included: plant growth, height, and stem diameter above the graft union. Ten months after grafting, the statistical analysis showed significant differences in height between grafted and non-grafted plants but not on stem diameter. The high compatibility of grafted plants showed similar growth in grafted and non-grafted plants. *Jatropha* ungrafted and grafted differed significantly in weight,
but they were similar in diameter and length. Oil yield did not differ significantly; however, more oil could be obtained if we consider that the seeds of grafted plants are heavier. The grafting method improves *Jatropha curcas* height and seed weight, and it does not affect germ oil percentage. Therefore, the use of grafted plants is an excellent option for plantation establishment and production in less time with homogeneous yields.

**(366) Are There Advantages to Altering Planting Arrangement of Sweet Sorghum?**

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Sweet sorghum [*Sorghum bicolor* (L.) Moench] has been an attractive crop for the biofuel industry due to high yields of fermentable juice and fibrous biomass, with lower requirements than other crops. Previous work has shown that stalks planted closer together in regular rows are thinner, weigh less, and yield less juice than ones planted further apart, but are more susceptible to lodging, which is a substantial barrier to harvesting. Some crops grown in hills or clumps benefit from conservation of soil moisture and mutual shading, especially in marginal or arid climates. This study examined the effects of planting sweet sorghum in clumps compared to regular rows. Four varieties (Cowley, Hodo, M81E, and Mer74-2) were sown on 6 May 2015, in a split-split design, with arrangement (hill or normal) as main plot and variety as sub-plot, with four replications. Normal rows were planted at 18 seeds/m. Hills were hand-planted as a cluster of three to five seed every 0.5 m. Each variety was harvested 30 days after half of the plants were flowering. A 3.05 m section from one harvest row (out of four-row plots) was cut at the soil line and weighed. A subsample was weighed with and without leaves and panicles. Stem diameters were measured before the stalks were passed through a roller mill and juice collected and weighed. Juice samples were analyzed by HPLC for sugars. Stems in the hills were significantly heavier than those in the normal rows. Weights of the subsamples and juice were also significantly higher in the hills. However, field weight showed no significant difference between treatments. Plants in normal rows were smaller but there were more of them per area. There were no differences in number of leaves, but the overall weight was significantly different, due to leaf width and area, but not length. Overall rate of lodging was significantly lower in the hills (11.2% vs. 59.4%), indicating that stalks in clumps might offer each other support, or that thicker ones are less susceptible to lodging. No difference was found in fructose, glucose, or sucrose between treatments. For sweet sorghum grown in Arizona, greater water use efficiency and leaf area appear to be two advantages of planting in clumps, yielding thicker, sturdier stalks with more juice. Possible drawbacks include an increase in weeds between groupings, difficulty pressing large stalks, and adapting the current commercial planting machinery.

**(367) Effect of Cover Crops and Nitrogen Fertilization on Juice Yield, Sugar Content, and Biomass Yield of Sweet Sorghum**

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The purpose of the study was to analyze the effect of cover crops and nitrogen fertilization on sweet sorghum biomass yield, amount of juice produced, and sugar components in the juice (sucrose fructose and glucose) when grown on a marginal land. The sweet sorghum was planted in 2013 at Fort Valley State University research farm with 4 cover crops (control, rye, vetch, and rye + vetch mix) and 2 nitrogen rates (control vs. 90 kg/ha) with 3 replications. Juice was extracted from 20 plants per plot. The extracted juice was analyzed for sucrose, glucose and fructose using high performance liquid chromatography (HPLC). The analysis of variance (ANOVA) for role of nitrogen fertilizers showed no significant difference between control and 90 Kg N/ha for biomass yield, juice yield, sucrose, glucose, and fructose content. Cover crops, when compared to no cover crops, showed no significant difference except for sucrose content at 90% confidence interval. Biomass yield was found significantly different only for vetch and rye treatments. In addition, when sugar components were analyzed with respect to quantity of juice produced, no significant relationship was observed in terms of quantity of individual components. The results seem promising that sweet sorghum can be grown on marginal land in absence of cover crops and nitrogen fertilization without impacting biomass yield, amount of juice produced and sugar content in the juice. Further research is needed to validate the findings.

*Specified Source(s) of Funding*: USDA-NIFA-AFRI

**(368) Impact of Synthetic Nitrogen Rates on Fresh and Dry Weight Biomass Yield, Above-ground Plant Components, Physiological Parameters of Three Perennial Feedstock Biofuel Grass Species**

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The purpose of the study was to analyze the effect of nitrogen fertilization on fresh and dry weight biomass yield, above-ground plant components, and physiological parameters of three perennial feedstock biofuel grass species. The study was conducted at Fort Valley State University research farm with 3 nitrogen rates (control vs. 90 Kg N/ha) with 3 replications. The extracted biomass was analyzed for dry weight and fresh weight biomass yield. The above-ground plant components included grass leaf, stem, and panicle. The physiological parameters included net photosynthesis, stomatal conductance, intercellular CO2 concentration, and transpiration rate. The analysis of variance (ANOVA) was used to determine the significance of the differences between treatments. The results showed that nitrogen fertilization significantly increased fresh and dry weight biomass yield, above-ground plant components, and physiological parameters of all three biofuel grass species. The results suggest that nitrogen fertilization is an important factor in increasing the productivity of biofuel grass species.
The objective of this study was to evaluate how inorganic nitrogen fertilization rates effect fresh and dry weight yields (FWY and DWY), above ground plant components, photosynthesis (Pn), transpiration (E), conductance (C) and leaf area index (LAI) of perennial bio-fuel grass species giant reed (C1), napier grass (C2) and energy cane (C3). The nitrogen rates [zero N = 0N (no nitrogen), half N = HN (100 kg of N/ha) and full N = FN (200 kg/ha)] were applied to grass species using randomized complete-block design with four replications as follows: 1) C1-0N; 2) C2-0N; 3) C3-0N; 4) C1-HN; 5) C2-HN; 6) C3-HN; 7) C1-FN; 8) C2-FN; and 9) C3-FN. Significant ($P = 0.05$) differences occurred among treatments for FWY, DWY, stalk no./ha, culm fresh wt., stalk no./culm, stalk ht./culm, fresh wt./stall and LAI. Treatment C2-0N produced highest FWY and DWY (238.1 and 60.5 Mg/ha) while lowest FWY and DWY by C3-HN (58.4 and 15.6 Mg/ha, respectively). Treatment C1-0N produced maximum (481793) stalk no./ha with C3 at HN producing minimum stalk no./ha (211969). Treatments C2-0N produced highest culm fresh wt. (14.94 kg) and stalk no./culm (30.2) while lowest culm fresh wt. (3.67 kg) and stalk no./culm (13.30) was produced by C3-HN. C1-HN produced highest stalk ht./culm (356.7 cm) were by and C3-HN produced the east (171.0 cm). Maximum fresh wt./stall (489.1 g) was produced by C2-0N with C1-0N producing minimum (217.4 g) fresh wt. per stalk. Leaf Area Index was highest (5.2) for C2 at FN and lowest (2.5) for C3-0N. Physiological parameters were examined with C2-FN, C1-HN and C1-FN producing highest Pn (19.6 umol/m$^2$/s), E (2.7 mmol/m$^2$/s) and C (388.0 mmol/m$^2$/s). The results indicated that napier grass performed better than energy cane and giant reed with 0 nitrogen rate predominating for yield and above ground plant components while LAI and physiological parameters were effected the most by napier grass at full nitrogen. Further research is needed before conclusive recommendations are provided.

Specified Source(s) of Funding: USDA-NIFA-AFRI

(369) The Potential of Creating Bioenergy for Small Farmers through Gasification of Woody Plants and Wastes

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With the Increasing demand of energy coupled with declining fossil fuel resources of the planet, there is increasing interest in the identification of renewable energy resources derived from plant biomass and plant waste products. A number of woody invasive plant species may serve well for generating energy for farmers, as well as create a use for an invasive plant after its removal from ecosystems. Energy production from waste products such as wooden pallets could also reduce the need for additional resources. The objective of this study is to examine the potential of bush honeysuckle, pawpaw, white ash, and waste wood from pallets as feedstock in a gasifier, which was used to fuel a generator for electricity production. Bush honeysuckle (Lonicera maackii), which is an invasive woody bush of Kentucky, the North American pawpaw (Asimina triloba), which is a small native tree in Kentucky, and white ash (Fraxinus americana), a large native tree species in Kentucky, could serve as excellent feedstocks for gasification. Unloaded pallets are a common waste product at retail stores in Kentucky. All waste product feedstocks were examined and are capable of producing moderate amounts of electricity; however, the various gasification attributes of each woody species and pallet materials will be reported. Issues concerning the practicality and labor commitments for the operation of a gasification system will be discussed.

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Posters

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Posters

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(111) Genetic Diversity of a Germplasm Collection of Eremurus Using Molecular and Morphological Markers

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Eremurus is one of the most important genus of the family Asphodelaceae, including 45 species which grow in the Montainous area. Most species are of high horticultural potential. Eremurus is widely used in the Netherlands, Germany, Israel, Japan, Turkey, Iran, Central Asia and North and South America, especially as cut flowers. Iran is the third diversity centers of Eremurus genus with 7 species and 4 subspecies after the Soviet Union and Afghanistan. The greatest diversity of species are found in Northeast of Iran (Khorasan Provinces). Identification and evaluation of genetic diversity of the species of the genus Eremurus has not been addressed yet Therefore, in this study, identification and evaluation of the genetic diversity of Eremurus species in Iran with morphological and molecular marker will be considered. Eremurus species has been collected from 11 provinces of Iran including 29 accessions during Spring and early Summer 2015. AFLP analysis is going to applied to study genetic variation within and between species. The Eremurus species which has been identified up to now include E. luteus,
E. persicus, E. inderiensis, E. kopetdaghis, and E. stenophyllus subsp. stenophyllus. It has been found that E. stenophyllus subsp. stenophyllus, an endemic species in Khorasan province is at the risk of being extinct.

(112) Discovery of Allelic Variation in the Blueberry TFL1 Gene By Ecotilling
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TERMINAL FLOWER1 (TFL1) has been found to repress the transition from vegetative to reproductive growth in diverse plant species. Natural mutations of TFL1 orthologs cause repetitive flowering in rose and woodland strawberry and a determinate growth habit in soybean, tomato, and cowpea. We investigated allelic variation in blueberry TFL1 among accessions in the USDA Vaccinium germplasm collection. The VcTFL1 gene sequence was identified from the draft genomic sequence of diploid V. corymbosum line W85-20. VcTFL1 is a member of a PEBP gene family and could be distinguished from its family members by sequence comparison with PEBP family genes from other plants. To examine allelic variation, DNA was isolated from 160 Vaccinium accessions, most of which were autotetraploid V. corymbosum genotypes. For each accession, the four exons of VcTFL1 were amplified separately by PCR. Exons that differed in sequence from the W85-20 control were identified by high-resolution melting analysis. Single nucleotide polymorphisms (SNPs) were confirmed by sequencing. The analysis of tetraploid accessions with variant TFL1 alleles could distinguish simplex, duplex, and triplex haplotypes. A total of 18 SNPs were confirmed in VcTFL1 coding sequences among the 160 accessions. Three of these SNPs caused a change in an amino acid. The effect of these amino acid changes on protein function was examined with multiple bioinformatic tools. An alanine to valine change in exon 4 was predicted by these analyses to be deleterious to VcTFL1 function. The diploid V. corymbosum accession DE596 is heterozygous for this missense mutation. Exon 4 is critical to TFL1 function and is the site of missense mutations in soybean and cowpea that alter growth habit. The utility of V. corymbosum accession DE596 for developing an ornamental blueberry with novel flowering or architecture will be examined.

(113) Association Mapping of Aphid Resistance in USDA Cowpea (Vigna unguiculata L. Walp.) Core Collection Using SNPs
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Cowpea aphid (CPA; Aphis craccivora) is a destructive insect pest of cowpea, and also causes significant yield losses in other legume crops including alfalfa, beans, chickpea, lentils, lupins, and peanuts. The utilization of aphid resistance in cowpea breeding is one of the most efficiency and environmental friendly methods and using marker-assisted selection will expedite cowpea breeding procedure, but it is limited by the lack of information on marker associations of the aphid resistance. The objective of this study was to identify single nucleotide polymorphism (SNP) markers associated with aphid resistance in cowpea. In this study, 338 cowpea accessions from the cowpea core collection in USDA-GRIN, originally collected from 40 countries, were evaluated for their aphid resistance and 1047 SNPs identified from genotyping by sequencing (GBS) as the genotypic data. Single marker regression (SMR), general linear model (GLM), and mixed linear model (MLM) in TASSEL were used for association analysis between the SNPs and the phenotypic data. Three clusters were inferred by STRUCTURE analysis, in good agreement with the phylogenetic tree drown by MEGA 6 based on the maximum likelihood model with neighbor joining method. A genome-wide association study revealed two SNP markers, C35011941_894 and Scaffold30061_3363 were strongly associated with aphid resistance across three models with the log of odds (LOD) value greater than 2.5. The results will provide useful information for selecting aphid resistance in cowpea molecular breeding.

(115) Genetic Diversity Analysis in a Collection of Tomato Germplasm Using Indel Markers
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Cultivated tomato (Solanum lycopersicum L.) is an economically important vegetable crop all around the world. The two reference genome sequences of tomato, which were published in 2012, have leveraged marker development. Recently, a large number of Indels were identified through in silico analysis using the reference genome sequences. In this study, we investigated genetic diversity in a collection of 187 tomato accessions using the Indel markers. The tomato collection consisted of 174 cultivated varieties and 13 wild species (4 S. habrochaites, 1 S. arcanum, 4 S. chilense, 1 S. pimpinellifolium, and 3 S. peruvianum). The 174 cultivated varieties were derived from

An asterisk (*) following a name indicates the presenting author.
11 countries representing Russia (55 varieties), China (51 varieties), South Korea (33 varieties), Uzbekistan (20 varieties), and others (15 varieties). This germplasm collection was genotyped using the 31 Indel markers that were selected based on polymorphism and clear banding pattern. Principal component analysis (PCA) revealed that a high level of genetic variation was present in the cultivated tomato varieties. We also found two major clusters and that the tomato varieties from China, South Korea, Russia, and Uzbekistan were divided into these clusters. In addition, there was a minor cluster consisting of mainly the Chinese varieties. The wild species were distinct from all of these clusters. This genetic clustering was shown in the UPGMA dendrogram. These results suggest that our collection of cultivated tomatoes is a useful resource to develop a core collection for genetics and breeding in tomato.

(116) Novel Micro-RNAs Targeting to Genes Associated with Drought Stress in a Oil Crop Camelina sativa
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Camelina (Camelina sativa L.) belonging to the Brassicaceae has been cultivated for seed oil containing high unsaturated fatty acids. Small non-coding and single stranded miRNAs that regulate gene expression at posttranscriptional level were explored from the Camelina cDNA library under drought stress. A total of the predicted 145 miRNAs (61 conserved and 84 putative novel miRNAs) were found to be 28 and 72 different miRNA families, respectively. Most of the miRNAs were 21 nt long (54.4%), but their precursor sequences extended to 66 to 305 long. Fifty percentage of predicted novel miRNAs possessed uracil/thymine at first base position of their sequences, suggesting that they play a vital role in miRNA-mediated gene regulation. In silico prediction indicated that the 45 putative novel miRNAs have higher complimentary with gene coding sequences targeting 70 genes involved in stress resistance, lipid metabolism, and transcription factors. Some of the newly identified miRNA targets may be unique to the Camelina species. All target genes were highly up-regulated in well-watered control leaves where miRNAs showed relatively low expression. In contrast, target genes were down-regulated upon drought treatment at 10 kPa and 100 kPa, whereas miRNAs showed up-regulated expression. Coordinated expression changes between validated miRNAs and their counterpart target genes varied under drought conditions, suggesting that the predicted miRNAs in this study could be stress responsive and contribute to gene regulatory frameworks in response to drought stress in the Camelina.

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(117) Transcriptome Analysis Revealed the Dynamic Fruit Oil Accumulation of Symplocos paniculata
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Symplocos paniculata is a shrub or small tree with high fruit oil content. It can be used as potential feedstocks for biodiesel and cooking oil production in China. To understand the regulatory molecular mechanism of fruit oil accumulation, the transcriptome analysis was conducted using the fresh fruits at four different development stages (10, 80,140, and 170 days after flowering). Approximately 28 million high quality clean reads were generated, and they were trimmed and assembled into 182,904 non-redundant putative transcripts with a mean length of 592.91bp and N50 length of 785 bp, respectively. Based on the functional annotation through Basic Local Alignment Search Tool (BLAST) program with public protein database, the key enzymes involved in lipid metabolism were identified, and a schematic diagram of the pathway and temporal expression patterns of lipid metabolism was established. About 13,939 differentially expressed unigenes were screened out using DESeq method. The transcriptional regulatory patterns of the identified enzymes were comparatively analyzed with the dynamic oil accumulation along with the fruit development of S. paniculata. In addition, six vital genes related to lipid metabolism were selected and validated by quantitative real-time PCR (qRT-PCR). Results in this study will provide references for researching the woody oil plants.

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An asterisk (*) following a name indicates the presenting author.
In order to investigate genetic diversity and relatedness among walnut samples from different countries, ten microsatellite (SSR) loci were analyzed on 189 Persian walnut (*Juglans regia* L.) genotypes growing in 14 countries from three continents. The 10 SSR primer pairs were polymorphic and amplified 115 alleles, ranging from 3–25 per locus, with a mean value of 11.5 alleles per locus. The highest number of alleles (25) was observed in WGA32 locus, while WGA276 locus had the highest number of effective allele (7.6). PIC value ranged from 0.37 (WGA27) to 0.86 (WGA276) with an average of 0.69. Shannon’s information index ($I = 1.59$) revealed that diversity among walnut sampled from different country was high. The mean values of observed and expected heterozygosity were 0.62 and 0.73, respectively. According to the Nei’s genetic identity, samples from Greece and Germany showed the lowest identity (0.639), while samples from Algeria and Morocco had the highest similarity (0.968). Samples collected from Iran had the highest number of alleles (7.2) and number of private alleles (12), as well as the highest amount for Shannon index (1.6), indicating higher diversity in this population compare to other studied populations. The highest amount of observed heterozygosity (0.71) was recorded in Greece accessions. Cluster analysis divided genotypes in the line of geographical regions. STRUCTURE software confirmed the results of the UPGMA and divided accessions into two main groups and separated samples from Europe and North Africa from samples of Near East and Greece. This data provide comprehensive information about the genetic diversity as well as the model of walnut distribution between different nations.

**Poster Session—Growth Chambers and Controlled Environments 1**

**(207) Light-emitting Diodes As an Alternative to Cool-white Fluorescents for Healing of Grafted Tomato Transplants**

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Grafted tomato seedlings propagation must be optimized to increase production efficiencies. Grafting has several steps that include growing, grafting, healing, and acclimation. Healing is considered the most critical step. Healing is the joining of cambium between rootstock and scion to form vascular tissue and is commonly done under modified greenhouse conditions or inside healing chambers. Previous work determined that light during the healing period influences morphology and quality of grafted tomatoes. Cool white fluorescent (CWF) at a photosynthetic photon flux of 100 μmol·m⁻²·s⁻¹ is recommended for healing chambers. Light emitting diodes (LED) make possible optimizing the spectral requirements for healing. Tomato seedlings rootstock (cv. Maxifort) and scion (cv. Trust) were grown in the greenhouse at 13.3 ± 3.8 mol·m⁻²·d⁻¹ daily light integral, 23.6°C/18.67°C ±2°C (day/night) temperatures (T), and 38.6% ± 9.6% relative humidity (RH). After 19 days, tomatoes were grafted and placed inside a healing chamber under 27.7 °C ± 0.9 °C T and 98% + RH on day one and decreasing RH over seven days. During healing, the plants were exposed to six different light treatments. Four LED spectra with varied blue (B), green (G), and red (R) percent photon flux (PF) of 4B:5G:89R, 30B:2G:67R, 50B:50R and 76B:24R at 75 μmol·m⁻²·s⁻¹ PF. CWF was used as a control at 75 μmol·m⁻²·s⁻¹ (CWF-75), and 100 μmol·m⁻²·s⁻¹ (CWF-100) PF. Plant height and leaf number were measured pre and post healing on each grafted plant. In addition, dry mass, stem diameter, fresh mass, and leaf area were measured on a sub-sample pre grafting and on each plant post grafting. The %-increase from pre to post healing was calculated for all the plant parameters. Plants in CWF-100 had 61% greater height %-increase than in 50B:50R and 76B:24R. No differences were observed between plants in 4B:5G:89R, 30B:2G:67R, CWF-75 and CWF-100 in height %-increase. CWF-100 had 73% greater dry mass %-increase than CWF-75 and 30B:2G:67R. 50B:50R, 76B:24R, 4B:5G:89R at 75 μmol·m⁻²·s⁻¹ were not different from CWF-100 for dry mass %-increase. Plants in 4B:5G:89R had 94% greater plant compactness than in CWF-75 and 30B:2G:67R. Plants in 50B:50R, 76B:24R and 4B:5G:89R at 75 μmol·m⁻²·s⁻¹ were not different than in CWF-100 for plant compactness. This preliminary experiment shows that tomato plant quality during healing is comparable under LED (4B:5G:89R, 50B:50R , 76B:24R) at 75 μmol·m⁻²·s⁻¹ to CWF at 100 μmol·m⁻²·s⁻¹.

**(208) Supplemental Light Improves Yield and Quality of Chives in a Commercial Hydroponic Production System**

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Grower interest in narrow-band light emitting diode (LED) lighting systems is increasing due to projected energy savings over conventional lighting systems and the potential to improve yield and quality by manipulating the light available to optimize growth while minimizing potential light stress. The percentages of blue and red in narrow-band wavelengths of light from LEDs is recommended to 4B:5G:89R (4:5:89), 30B:2G:67R, 50B:50R and 76B:24R at 75 μmol·m⁻²·s⁻¹ to CWF at 100 μmol·m⁻²·s⁻¹.
have been shown to impact mineral uptake, pigment development, and the rate of growth and development of several plant species. Our objective was to determine the impact of supplemental light on the yield and quality of chives produced in a hydroponic system. In this experiment, chives (Allium schoenoprasum) were grown in a nutrient film hydroponic system with a complete nutrient solution under commercial greenhouse conditions. The following light treatments were utilized in this study: 1) natural sunlight; 2) high pressure sodium (HPS) lighting at 70 μmol·m⁻²·s⁻¹ intensity above natural sunlight intensity; 3) LED lighting at 70 μmol·m⁻²·s⁻¹ intensity above natural light with blue at 20% and red at 80%; and 4) LED lighting at 70 μmol·m⁻²·s⁻¹ intensity above natural light with blue at 21%, green at 23%, red at 50%, and far-red at 6%. The daily light integral (DLI) during the growth period in the greenhouse averaged 8.5 mol·m⁻²·d⁻¹ (ranging from 4 to 18 mol·m⁻²·d⁻¹). The supplemental light treatments each provided 6.05 mol·m⁻²·d⁻¹. Total shoot fresh weight and dry weight were twice as high in all supplemental light treatments compared to the natural sunlight treatment. Shoot fresh weight was 37% greater in the 20% blue/80% red LED treatment than in the HPS light treatment. Total carotenoid content was 20% higher in the 20% blue/80% red LED treatment than in the natural sunlight treatment. Carotenoid content was not significantly different between the natural sunlight and the HPS or the 20% blue/21% green/50% red/6% far-red supplemental light treatments. The impact of supplemental light treatments on individual carotenoids, chlorophyll a and b, and mineral content of chives will be discussed. This experiment demonstrates that supplemental lighting with narrow band LEDs improves the growth and quality of chives grown under commercial greenhouse conditions. Further research is warranted to determine the precise quantity and quality of light needed to maximize yield and quality of chives and to evaluate whether this yield and quality increase will be economically beneficial to the grower relative to lighting cost.

(209) Supplemental LED Lighting As a Potential Alternative to Plant Growth Regulators

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Supplemental lighting is commonly used for greenhouse transplant production. High pressure sodium fixtures (HPS) are the common lighting technology to supplement solar light. However, light emitting diodes (LED) are an alternative to HPS. Current advertised LED fixtures for supplemental greenhouse lighting are more efficient (μmol·J⁻¹) than HPS fixtures. LED fixtures can be built with customized spectrum providing the opportunity to manipulate plant morphology using light signals. Plant compactness is one of the most important morphological characteristics for transplant production. The use of chemical growth regulators (PGR) to decrease plant height is under high regulation as a result of their potential health risks. The use of supplemental lighting to increase plant compactness is a sound alternative to chemical PGRs. The objective of the present experiment was to compare plant growth and morphology under different supplemental lighting treatments and under PGRs in order to potentially reduce the use of PGRs in horticultural operations. Dianthus, geranium, pansy, petunia and salvia were grown in a greenhouse from seed until the plug stage under 9.2 ± 2.4 mol·m⁻²·d⁻¹ average solar daily light integral, 22.5 ± 2.4 °C average temperature, and 46 ± 16 % relative humidity. The six growing treatments consisted of: 1) 19% blue:81% red photon flux LED supplemental lighting, 2) 6% blue:5% green:89% red photon flux LED supplemental lighting, 3) HPS supplemental lighting, 4) no-supplemental lighting, 5) 6% blue:5% green:89% red photon flux LED + PGR and 5) no-supplemental lighting + PGR. All the supplemental lighting treatments delivered 100 μmol·m⁻²·s⁻¹ PF for 18 hours for a supplemental daily light integral of 6.5 mol·m⁻²·d⁻¹. Plant physiological responses, such as dry mass, fresh mass, leaf number, leaf area, plant height, stem diameter, plant compactness, anthocyanin concentration, and chlorophyll concentration were measured for all the crops. The results comparing the different supplemental light treatments with the PGR treatments will be presented.

(210) Response of Greenhouse Tomato Photosynthesis to Different Spectra of Intra-canopy LEDs Under Different Ratios of Red-Blue-White Overhead LEDs

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Different light spectra trigger different plant growth and physiological processes. Therefore, the optimum spectral compositions for different growth processes or plants at different growth stages may be different. Greenhouse tomato (Solanum lycopersicum) is a tall crop; most of the growth in early growth stage is leaf/vegetative growth while both leaf and fruit (generative) growth occurs in mid to late growth stage once the plant reaching full canopy. The leaf growth mostly occurs in the top canopy while fruit growth in the middle and bottom canopy. Therefore, optimized seasonal and vertical spectral distribution profiles could
be developed for improving both vegetative and fruit growth. In this study, we investigated the effects of seasonal variations of overhead LED spectra (placed above crop canopy) and different spectra of intra-canopy LEDs (placed inside the canopy near the developing cluster of fruit) on leaf photosynthesis of greenhouse tomato from October 2015 to February 2016 in a large greenhouse (200m²). The greenhouse was divided into 4 sections (50m²/section). Two seasonal overhead LED spectral treatments with red-blue-white ratios ranging from 10:0:0 (full red) to 6:2:1 were applied right after planting (2sections/treatment). Four intra-canopy LED treatments (blue, red, white and UV-A) were applied to the 4 plots (24 stems/plot) inside each section when a full crop canopy had developed. The two overhead LED treatments provided 140 µmol·m⁻²·s⁻¹ while the blue, red and white intra-canopy LEDs provided 10 µmol·m⁻²·s⁻¹ of light. The UV-A LEDs provided 8 µmol·m⁻²·s⁻¹ of light. The photosynthesis of the fifth fully expanded leaf was measured with a portable photosynthesis measurement system. Adding blue light or high blue to red overhead light ratios increased leaf photosynthesis over 100% of red light. The blue intra-canopy LED treatment had the highest photosynthesis, while the white LED treatment had the lowest photosynthesis. The leaves grown with more blue light also were thicker and had higher leaf chlorophyll than those grown under red or white LEDs. Therefore, adding blue light inside crop canopy could also increase plant photosynthesis and productivity, in addition to the beneficial effects on fruit quality discovered in our early study.

(211) Effects of Different Spectra of Supplemental Lighting on Water Use Efficiency of Lettuce Lactuca sativa L. ‘Cherokee’ in the Greenhouse

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Successful plant production depends on providing adequate environmental conditions for plant growth. In low-light environments, growth and development of greenhouse (GH)-grown vegetables is enhanced by use of supplemental lighting (SL), which helps to increase the total daily light integral (DLI) that plants receive. Studies have examined growth and morphological responses of different vegetables using light-emitting diodes (LEDs) as SL sources. However, the effect of LED SL on water uptake has not been determined. Since physiological changes in response to differences in light spectra have been reported, light spectra from SL may play a key role regulating water relations in plants by inducing changes in stomatal conductance and transpiration. The objective of this study is to quantify growth, leaf gas-exchange responses, and water requirements of lettuce (Lactuca sativa L. ‘Cherokee’) plants grown under one of five SL treatments. A variant solar DLI will occur naturally for all treatments, and a constant DLI of 2.6 mol·m⁻²·d⁻¹ will be provided to all plants receiving SL. Plants will be grown in a glass-glazed GH for 3 weeks and water applications will be monitored based on the available water in each container. Results from this experiment reflecting growth, water requirement and gas exchange will be presented.

(212) LED Light Quality Impacts Plant Content of Nutritionally Important Pigments in Sprouting Broccoli

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Light-emitting diodes (LED) are an alternative choice for lighting in controlled environments with the added benefit of light quality management. Many studies now show changes in light quality can impact secondary metabolite accumulation in specialty leafy crops. The objective of this study was to compare impacts of white LEDs with different ratios of blue/red LEDs on the content of nutritionally important pigments in Sprouting broccoli (Brassica oleracea var italic). Broccoli were seeded into soil-less media and germinated under greenhouse conditions before transfer to controlled environment chambers 7 days after seeding (DAS). Experimental sole source LED light quality treatments were: 1) white; 2) 5% blue (447 nm) / 95% red (627 nm); 3) 10% blue / 90% red; 4) 20% blue / 80% red; 5) 40% blue / 60% red; and 6) 60% blue / 40% red, with a 14-hour photoperiod and a light intensity of 250 µmol·m⁻²·s⁻¹ for all treatments. The experiment was repeated three times. All plants were harvested 30 DAS. Broccoli plant shoot fresh mass (P = 0.033) varied in response to light quality treatments. Because of the impacts of light quality treatments on shoot fresh mass, pigments were analyzed on a per plant fresh mass content. The content of antheraxanthin (P = 0.002), β-carotene (P = 0.032), chlorophyll a (P = 0.014), chlorophyll b (P = 0.009), lutein (P = 0.035), zeaxanthin (P = 0.016), and the pool of xanthophyll cycle pigments (zeaxanthin + antheraxanthin + violaxanthin; P = 0.054) within the Sprouting broccoli plants varied with changes in LED light quality. The 5% blue/95% red treatment resulted in higher content for most pigments compared to all other light treatments. Interestingly, the content of zeaxanthin in the broccoli was higher under broad-spectrum white LEDs as compared to all other narrow-band light treatments. The xanthophyll cycle pigments are vital for energy dissipation of excess absorbed light, and zeaxanthin is directly involved in preventing photo-oxidative stress. Application of LEDs and proper management of light quality may be beneficial for improving the nutritional quality of the broccoli.
content of baby leafy greens in controlled environments.

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(213) Management of LED Light Quality to Maximize Biomass and Chlorophyll Fluorescence in Sprouting Broccoli in Controlled Environments
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Light quality plays a major role in plant growth and development in controlled environments. Previous work by our group has shown blue/red wavelengths from light-emitting diodes (LED) influence biomass production in brassica microgreens differently than traditional fluorescent and incandescent lighting. The objective of this study was to compare impacts of white LEDs with different ratios of blue/red LEDs on biomass and chlorophyll fluorescence parameters in Sprouting broccoli (Brassica oleracea var. italica). Broccoli were seeded into soilless media and grown for 7 days in greenhouse conditions before transfer to controlled environment chambers. Chambers were set at an air temperature of 22 °C under a 14-hour photoperiod using a light intensity of 250 µmol·m⁻²·s⁻¹. Experimental sole source LED light quality treatments were: 1) white; 2) 5% blue (447 ± 5 nm) / 95% red; 3) 10% blue / 90% red; 4) 20% blue / 80% red; 5) 40% blue / 60% red; and 6) 60% blue / 40% red. The experiment was repeated three times. All plants were harvested 30 days after seeding and shoot tissues were measured for height, fresh mass (FM), and chlorophyll fluorescence parameters. Broccoli plant height (P ≤ 0.001) and shoot fresh mass (P ≤ 0.001) varied in response to light quality treatments. Plants under the 5% blue/95% red treatment had the tallest height at an average of 16.1 cm, while plants under the 40% blue/60% red treatment had the lowest height (13.5 cm). The highest shoot FM was found for plants under the 5% blue/95% red treatment, while the lowest shoot FM was under the 60% blue/40% red treatment. Shoot tissue minimum fluorescence (Fₚₒ; P ≤ 0.001), maximum fluorescence (Fₚᵢ; P ≤ 0.001), variable fluorescence (Fᵥᵦ; P ≤ 0.001), and maximum quantum yield of PSII (Fᵥᵦ/Fₚᵢ; P = 0.02) were all influenced by light treatment. The 5% blue/95% red treatment resulted in significantly higher Fₚₒ, Fₚᵢ, Fᵥᵦ, and Fᵥᵦ/Fₚᵢ values compared to all other light treatments. The 40% blue/60% red treatment produced the lowest values for Fₒ, Fₚᵢ, Fᵥᵦ, and Fᵥᵦ/Fₚᵢ compared to all other light treatments. Sole source 5% blue/95% red lighting resulted in the highest plant growth and chlorophyll fluorescence in baby Sprouting broccoli. Higher ratios of blue light decreased broccoli height and shoot FM, which may be due to the influence of blue light stimuli on stem elongation and stomatal regulation. Therefore, proper management of blue/red LED lighting ratios may be beneficial to baby leafy green production in controlled environments.

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(214) Comparison of LED and HPS Supplemental Light Quality on Greenhouse Tomato Production in Northern States during Winter Months
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Plant production under controlled environments is rapidly expanding throughout the world and provides opportunity to meet the growing demands for locally grown fresh produce year-round. Tomato is one of the most economically important crops, which requires a Daily Light Integral (DLI) of 25 mol·m⁻²·d⁻¹ for optimal production. However, low DLI during winter months in northern states can significantly limit the production of tomatoes. The objectives of this study were to compare high-wire tomato (Solanum lycopersicum) production with and without supplemental lighting (control) during a fall to winter period and to evaluate the impact of light qualities and light sources [traditional overhead high-pressure sodium (HPS) lighting lamps vs. light-emitting diode (LED) intracanopy lighting towers] on several production parameters for commercial greenhouse tomato production. Supplemental LED lighting treatments were provided as different combinations of blue (B) and red (R) spectra of photosynthetically photon flux density (PPFD) at 230 µmol·s⁻¹·m⁻² in combination with far red (FR). Light treatments consisted of blue (100B:60R:0FR), red (0B:100R:0FR); 50% Far-red (0B:100R:50FR); 100% Far-red (0B:100R:100FR); and HPS and un-supplemented controls (0B:0R:0FR). Plant vegetative growth characteristics such as plant height, length of fully expanded leaves, and chlorophyll content were significantly increased with increasing FR and the values were similar to those from HPS treated plants. Total fruit yield per plant was increased by 300% in Red and by 275% in Blue compared to un-supplemented control. There was no significant difference between LED and HPS lightings in terms of total fruit yield with exceptions of Blue and in which fruit yield was reduced on an average by 5% compared to other LED treatments. The largest fruit clusters were obtained from plants grown with 100% Far Red, while un-supplemented control produced significantly smaller clusters. There was no difference in cluster size between other LED treatments and HPS. It is concluded that supplemental LED can produce equal or better greenhouse tomato yield and quality compared to HPS.

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

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**Poster Session—Growth Regulators in Fruit and Nut Production**

(243) **AVG Reduced Ethylene Production Rates of Pear Flowers and Fruitlets and Increased Fruit Set When Applied One to Two Weeks after Bloom**

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The European pear (*Pyrus communis* L.) cultivars ‘d’Anjou’ and ‘Comice’ have low fruit set, particularly during the first ten years from planting. Establishing these cultivars in high-density orchards, therefore, is impractical given insufficient crop loads to control vegetative growth. Over several years, we tested the hypothesis that applications of amino-ethoxy-vinyl-glycine (AVG) would improve fruit set of Comice and ‘d’Anjou’. We had two main objectives: To characterize the ethylene production rate of untreated and AVG-treated flowers and fruitlets during development, and to determine the most efficacious rates and timings of AVG. The pattern of ethylene production rate was consistent in all years, beginning around 0.5 µL·kg⁻¹·h⁻¹ at anthesis, peaking ~14 days after anthesis, and rapidly declining to undetectable levels within a few days. Ethylene production rates of ‘Comice’ were generally higher than ‘d’Anjou’ but peak amplitude varied among years, irrespective of cultivar. AVG practically eliminated ethylene production within hours of application. Respiration rates of flowers and fruitlets, on the other hand, were unaffected by AVG. In two of three years, ethylene production was reduced between 50% and 90% for >10 days after application; however, in one year the effect persisted for only two days. Generally, maximum effects were observed at rates of 60 ppm AVG. AVG applications at anthesis did not improve fruit set, irrespective of rate (30, 60, 90, 120 ppm) compared to untreated controls. Applications between one and two weeks after anthesis, however, led to a marked increase in fruit set in 70% of trials. Harvested fruits from AVG-treated trees had an equivalent number of seeds as untreated fruits, indicating that the usual poor fruit set of ‘d’Anjou’ and ‘Comice’ was not associated with pollination or fertilization issues. Fruit size was only significantly reduced by AVG when crop loads were excessive. Return bloom was unaffected by AVG, irrespective of rate, timing or cultivar.

*Specified Source(s) of Funding:* HATCH

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**Poster Session—Organic Horticulture 1**

(077) **Mulching Strategies Using Conservation Tillage for Weed Management in Tropical Organic Hot Pepper Cropping Systems**

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Soil conservation and effective weed management are generally conflicting objectives in tropical organic cropping systems where tillage is the primary means for weed suppression. Cover crops, conservation tillage, and mulching are known practices that provide numerous ecosystem services, but are seldom incorporated together into an integrated cropping system plan. The primary objective of this research is to evaluate a holistic approach to soil conservation that provides weed suppression in tropical organic cropping systems. Experiments were conducted at the Agricultural Experiment Station on St. Croix, VI, in 2015 and 2016 at two independent field sites. Trials began with the establishment of sunn hemp (*Crotalaria juncea* L.) in all...
experimental areas on 16 Oct. 2015, and terminated on 11 Jan. 2016. Four treatments were arranged in a RCB split with two weed removal frequencies (1 and 3 weeks), and replicated three times. Treatments included: 1) sunn hemp mulch (SHM), 2) sunn hemp mulch plus hay (SHM+hay), 3) sunn hemp mulch plus black landscape fabric (SHM+fabric) and 4) sunn hemp mowed and incorporated that served as a check plot (SH+none). Sunn hemp mulch was generated using a no-till roller-crimper. Peppers (*Capsicum annum*) were transplanted into treatments on 14 Jan. 2016. Following treatment establishment, irrigation was performed using weather-based evapotranspiration calculations and fertigation was used in accordance with best management practice recommendations. Above-ground biomass of sunn hemp at termination did not differ between fields; and measured 3717 kg·ha⁻¹ in field 1 and 4367 kg·ha⁻¹ in field 2. In-bed weed suppression at three weeks after pepper transplant (WAT) was greatest for SHM+fabric, followed by SHM+hay, and lowest for SHM and SH+none treatments. At six WAT, SHM+fabric provided the greatest weed suppression with similar results for the remaining three treatments in field 1. In Field 2, SHM+fabric suppressed weeds as well as SH+none and SHM+hay. A similar trend was observed at nine WAT for both fields as described for field 1. Low frequency weeding at three-week intervals was generally as effective as weekly weed removal resulting in similar pepper yields. Overall, the SHM+fabric and SHM+hay treatments had the greatest Jalapeno yields with no differences between the SHM and SH+none treatments. Serrano pepper yields were greatest in the SHM+fabric, followed by SHM+hay, and lowest for SHM and SH+none treatments. At six WAT, SHM+fabric provided the greatest weed suppression with similar results for the remaining three treatments in field 1. In Field 2, SHM+fabric suppressed weeds as well as SH+none and SHM+hay. A similar trend was observed at nine WAT for both fields as described for field 1. Low frequency weeding at three-week intervals was generally as effective as weekly weed removal resulting in similar pepper yields. Overall, the SHM+fabric and SHM+hay treatments had the greatest Jalapeno yields with no differences between the SHM and SH+none treatments. Serrano pepper yields were greatest in the SHM+fabric, followed by SHM+hay, and lowest for SHM and SH+none treatments; with the lowest yields recorded in the SHM treatment. Results indicate that soil conservation need not be compromised at the expense of weed suppression through the implementation of integrated mulching strategies.

Specified Source(s) of Funding: Sustainable Agriculture Research and Education Program


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Grower interest in reduced tillage techniques stems from concern over soil quality and energy use. Tillage decimates large-bodied soil organisms, reduces soil carbon storage and weakens the stability of aggregates. Organic vegetable growers in the Pacific Northwest currently pass over their fields 10–20 times annually to incorporate cover crops and amendments, prepare the soil for planting, and manage weeds. Incorporating reduced tillage into organic vegetable cropping systems requires careful integration of cover crops and specific implements. The specific objectives of this study were to identify production methods that effectively integrate cover crops and reduced tillage technologies to improve soil quality while reducing in-season weed pressure and seed bank populations. Cover crop variety trials indicated that ‘Aroostook’ rye and ‘Lana’ vetch were desirable cover crops for organic reduced tillage. Winter squash ‘Delicata’ and broccoli ‘Everest’ were grown in rotation with rye and vetch cover crops over a three-year period (2012–14) in Puyallup, WA. Cover crops were terminated with either a roller/crimper or flail mower and ground was prepared for transplants by strip till, no-till, or full till. Among reduced-tillage treatments, squash yield was increased with flail mowing compared to rolling/crimping in 2 out of 3 years. Full tillage had greater squash yields than reduced tillage treatments in 2 out of 3 years. Cover crop termination and reduced tillage combinations did not affect broccoli yields during any of the 3 years of the trial. Mulch created from terminating cover crops did not completely suppress weeds. High-residue cultivation could improve in-season weed control and yields in reduced-tillage organic vegetable production.

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(079) ESO-Cuc, the Eastern Sustainable Organic Cucurbit Project

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Organic growers are facing many challenges limiting their production of cucumbers, melons, and squash. Each year, aphid-vectored viruses, striped cucumber beetles, and downy mildew challenge these growers in the eastern United States. To help address these pests, the NIFA-OREI sponsored grant known as ESO-Cuc, the Eastern Sustainable Organic Cucurbit Project, is underway. ESO-Cuc is a multi-disciplinary, multi-institutional collaboration of plant pathologists, entomologists, extension specialists, and plant breeders at Auburn, Cornell and North Carolina State Universities, partnered with eOrganic and the Organic Seed Alliance, working to help growers producing organic zucchini/summer squash, melon and cucumbers in the eastern United States. Popular cucurbit cultivars, with consumer-desired characteristics, often lack genetic resistance to pests. We are working to develop open-pollinated cultivars that are regionally adapted, tolerant to pests, flavorful and prolific. A key to making this process work is grower input. We determine what seeds need improvement by using a blend of surveys at grower meetings and conferences, needs assessments by the Organic Seed Alliance, and the direct feedback we get through on-farm evaluations of varieties during development. A critical lens on this process comes from research being conducted directly on these insects and pathogens and their nexus with cultural practices. Our job is to strengthen these classic favorites, characterize these pests, and present management strategies most suited for 21st century organic production.

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**Impact of Fertilizer Regime on Yield and Food Safety of Heirloom Tomato Grown on Conventional and Organic Field Sites**

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In recent years, American consumer trends have indicated a rise in food nutrition awareness and organic produce, particularly with agricultural commodities. This increased sensitivity has led to a greater demand for agricultural food grown without the addition of synthesized products, or rather those that are raised using organic methods. Due to limited access and availability of approved organic fertilizers, many farmers resort to the use of natural sources, such as animal manure for nutrient enrichment. This practice introduces its own set of challenges, namely the potential to be a harbor for pathogenic bacteria, which can subsequently contaminate crops and is an avenue for water source pollution through runoff. These challenges have validated the need to research alternative fertilizer sources, in addition to manure, to determine their effects on crop growth as well as the likelihood for pathogen contamination. In this study, two approved organic fertilizers and a synthetic conventional fertilizer were used in comparison and conjunction with poultry manure to examine their effects on Debarao Plum and Brandywine tomato, (Lycopersicon esculentum) yield and microbial integrity, as grown organically and conventionally. Results indicate that fertilizer regime had no significant impact on overall tomato yield in either conventional (ranging from 2207 to 5081 kg/ha) or organic (ranging from 8165 to 9759 kg/ha) growth operations. Microbial integrity also proved to be of no consequence as fertilizer type had no significant influence on tomato fruit quality. Salmonella and generic E. coli were not detected on tomato fruits; however, generic E. coli was detected randomly in soil samples of a few tomato plots. Conclusions from this study indicated that fertilizer source does not contribute to productivity of Debarao Plum or Brandywine tomato varieties as long as the crop’s nutrient requirements are met. In addition, fertilizer type had no direct influence on pathogen contamination. Factors to consider in this finding are the age of poultry manure used, the amount of time that lapses between manure application and crop harvest, and whether the manure was treated with any process that would create a non-conducive environment for bacteria proliferation.

**Including Low Tunnels in a High Tunnel for Winter Strawberry Production in Cold Hardiness Zone Seven**

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Winter production of organically managed strawberries has been proven feasible and profitable in hardiness zone seven of North Carolina. However, cold damage to open blossoms was inevitable, and a damage rate of 61.5% has occurred in our previous study. The objective of this project was to investigate the possibility of including low tunnels inside high tunnels for reliable winter protection of strawberries. Tips of four strawberry cultivars Albion, San Andrea, Radiance and Winterstar were collected from a commercial nursery and rooted in a greenhouse for plug production. Resulting plugs were transplanted in a 30’ x 96’ x 8’ high tunnel. Six raised beds were made, and three of them were assigned randomly for low tunnel installation. The experiment was conducted as a completely randomized design. The treatment design was a split-plot design, with low tunnels/control (without low tunnels) as main plots and cultivars as split plot. There are 40 plants in each split plot. Low tunnels were installed on 23 Nov. 2015. There were no interactions between low tunnel and
cultivar treatments. Preliminary results indicated that there were no significant differences between the low tunnel and control treatment in terms of the first harvest date, marketable yield, total yield and cold damage to open blossoms. However, the numerical values consistently favored the low tunnel treatment. For example, the total yield and marketable yield were 2.99 and 2.84 kg/rep in the low tunnel treatment, compared to 2.27 and 2.15 kg/rep in the control. Low tunnel also advanced the first harvest by five days. There were significant differences between cultivars on the date of first harvest and flower damage. ‘Radiance’ and ‘San Andrea’ were harvested 10 days earlier than ‘Abion’ and ‘Winterstar’; ‘Radiance’ had most severe flower damage (74.6% on 24 Feb. and 40.7% on 28 Jan.) while ‘San Andrea’ had the least (47.8% and 23.8%, respectively). Microclimate factors such as low air temperature, soil temperature and solar radiation were measured with Spectrum® data loggers and sensors every 30 minutes. Data suggested additional protections would be provided by the low tunnels. The ins and outs of including low tunnels in high tunnels on winter production of strawberries in terms of winter and spring production, plant growth, and pest challenges will be discussed.

(082) Determining the Ideal Transplanting Dates for Organic Tomato Production in High Tunnels in North Carolina
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Tomato is one of the most important and profitable vegetable crops in high tunnel production. Information on planting dates of tomatoes in the Midwest has been well documented. Similar information in zone 7&8 of North Carolina, however, was very limited. The objective of this project was to determine the best transplanting time for tomato production in high tunnels for both spring and fall, and to explore the economic potential of growing tomato in organic high tunnels. Indeterminate tomato ‘Rabelski’ and ‘Big Beef’ were chosen for spring production while determinate tomato ‘Oregon Spring’ and ‘Defiant PHR’ ‘Rabelski’ and ‘Big Beef’ were chosen for spring production growing tomato in organic high tunnels. Indeterminate tomato both spring and fall, and to explore the economic potential of transplanting time for tomato production in high tunnels for limited. The objective of this project was to determine the best information in zone 7&8 of North Carolina, however, was very limited. The ins and outs of including low tunnels in high tunnels on winter production of strawberries in terms of winter and spring production, plant growth, and pest challenges will be discussed.

(083) Evaluation of Organic Weed Control Methods in Pecan Production
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Rising demand for organic commodities has led to the reevaluation of standard agricultural practices in order to meet this demand. In order for organic pecan production to be a viable enterprise several factors must be addressed in pecan cultivation including orchard floor management. Traditionally, in pecan orchards, a large portion of each row is maintained weed-free with herbicide applications while vegetation between rows is regularly mowed. An experiment was conducted from 28 Sept. 2013 to 24 July 2015, to determine efficacy of organic weed control methods in pecan orchards. Evaluated methods included mowed sod, flame control, pine bark mulch, vinegar herbicide, and pine bark mulch in combination with vinegar herbicide. Mowing, flame control, and a vinegar herbicide were applied at regular intervals during the course of the experiment while pine bark mulch was applied once at experiment initiation. Data were collected at each treatment application date. Large dicotyledonous species including Cinnamomum camphora (L.) Siebold, Sapium sebiferum (L.) Roxburgh, and Rubus spp. were hand removed from plots, as needed. The experiment was a randomized complete-block design with five blocks. Data were subjected to analysis of variance in JMP Pro 12 and means were separated using Tukey’s HSD (α = 0.05). The combination of pine bark mulch and vinegar herbicide improved weed control in plots compared with other treatments. Plots were kept, on average, 70% weed-free with combination of pine bark and vinegar herbicide compared with only 15%, 41%, 50%, and 27% for mowed sod, flame control, pine bark mulch (alone), and vinegar herbicide (alone), respectively. Weed species varied in prevalence in treated plots but all treatments decreased prevalence of dicotyledonous species compared with mowing which provided the least control. Bermudagrass [Cynodon dactylon (L.) Persoon] was the most prevalent monocot species and was controlled most effectively by the combination of pine bark and vinegar. Although pine bark mulch, especially in combination with vinegar herbicide, provided the best weed control, bark

An asterisk (*) following a name indicates the presenting author.
interfered with pecan harvest. Pine bark in combination with vinegar herbicide is the best available organic option for weed control, but should be limited to use during orchard establishment. Regular mowing, while not especially effective in weed control, is the best option evaluated for floor management in a mature, organic pecan orchard.

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

### Poster Session—Postharvest 1

**166** Effect of Maturity on Total Carotenoid Content of Selected Genomically Diverse Banana Cultivated in Southeastern United States

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Banana (**Musa** spp.) is the fourth most important fruit crop globally with respect to human nutrition. High carotenoid concentrations in foods are associated with reduced incidence of non-communicable chronic disease, including certain cancers, cardiovascular disease, and diabetes. There is a critical need for identification, determination and selection of carotenoid enriched banana cultivars adaptable to southeastern United States. Additionally, stage of maturity may have a profound influence on bioactive compounds in banana fruit. However, there is limited information concerning the effect of maturity on pulp total carotenoid content of diverse cultivars adaptable to southeastern United States. Therefore, collaborative research efforts between Alabama, Florida, Georgia, Hawaii, and North Dakota was initiated to identify underutilized carotenoid enriched banana cultivars adaptable to southeastern United States and destined for development of local niche market. Banana fruit cultivars varying in genotype ‘FHIA’ (AAAB), ‘Hua Mua’ (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% RH (mature green MG, transition TR, ripe R and over-ripe OR) and analyzed for total carotenoid content. There was significant (**P** ≤ 0.05) cultivar by maturity stage interaction for pulp total carotenoid content. Highest total carotenoid content with respect to cultivar was observed in ‘Pisang Raja’ (AAB), Hua Mua (AAB) and FHIA (AAAB). Mean total carotenoid content ranged from 46.36 to 183.85 µg/gfw. The lowest total carotenoid content with respect to maturity was observed in MG ‘Kandarian’ (ABB) and highest in fruit of OR ‘Hua Mua’ (AAB). Preliminary results from this study illustrate the importance of cultivar selection and maturity of banana cultivars adaptable to southeastern United States for potential local niche market and health enhancement of geographically diverse populations. It is therefore, vital to propose further research characterizing pulp carotenoid composition as related to maturity and cultivar in order to extend our knowledge and understanding of these variables on consumer demand, acceptance and shelf life.

**167** Impact of Harvesting Time on the Levels of Nitrate and Flavonoids in Spinach

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Health promoting compounds present in leafy vegetables are beneficial to maintain optimum health. Spinach (**Spinacia oleracea**), a green leafy vegetable, is a rich source with health promoting compounds such as nitrate, flavonoids, carotenoid, ascorbic acid and vitamins but their composition varies with different harvesting time. Flavonoids reported to exhibit antiviral, anti-cancer, anti-inflammatory, and anti-allergic activities. Nitrates maintain cardiovascular health and increasing muscle efficiency. In the current study, the levels of nitrate and flavonoids were measured in spinach at different growing time in the season was investigated. Spinach samples were different (20, 30, 40, 50, and 60 days) harvested period. Nitrate and flavonoids were extracted with water and methanol respectively and analyzed by reversed phase high performance liquid chromatography (HPLC) and compounds were separated on C18 column. Results demonstrated that the harvesting time had significant effect on the nitrate levels increasing from day 20 days (954 µg·g⁻¹) to 40 days (1833 µg·g⁻¹) and then decreased (487 µg·g⁻¹) at 60 days. A total 12 different flavonoids were identified in spinach by HPLC-high resolution mass spectra by positive and negative mode. The concentration of flavonoids varied among the sample collected at different harvesting time. For example 5,3,4 -Trihydroxy-3-methoxy-6,7-methylenedioxyflavone-4-β-D-glucuronide is the major flavonoid in spinach among other

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flavonoids. Spinach harvested at an early stage (between 20 to 30 days) has higher levels of nitrate and flavonoids as compared to spinach harvested at later. It is clear from present study; the harvesting period has major impact to consider in determining the levels of health promoting compounds.

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(168) Identification and Characterization of the Lipoxygenase Gene Family during Development of Pepino (Solanum muricatum Aiton)

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Pepino is a diploid (2n = 24) subtropical species, also known as melon pear, melon shrub or sweet cucumber, native species from South America specifically from The Andes area of Peru and Chile. Pepino fruit belongs to the Solanaceae family, which includes many important crops such as tomato and potato. Many aroma volatiles in fresh fruit are produced via the lipoxygenase (LOX) pathway. LOX genes are classified according to their function and grouped in the 13-LOX and the 9-LOX pathways, which generate C6 and C9 aroma compounds, respectively. Most of the LOX-derived compounds found in fruit aroma profiles are derived from the 13-LOX branch. The aims of this study were (i) to characterize the LOX gene family throughout development in flesh and peel of pepino fruit, and (ii) to investigate the relationship between LOX gene expression and the aroma volatiles emitted by the fruit. Two different studies were performed: (i) Six phenological stages were evaluated from immature fruit (2 days after fruit set) to senescent fruit (65 days after fruit set), and (ii) fruit of two maturity stages were collected (M1 = green background and M2 = white background) at commercial harvest, ripened at 20 °C and evaluated every two days for 15 days. All fruit were collected from Ovalle (IV Region) North of Chile, and analyzed for respiration rate, internal ethylene production, and quality parameters. Nine candidate LOX genes were identified using heterologous and degenerated primers designed from the closest family members (tomato and tobacco). We isolated RNA from pepino peel and flesh of the two different experiments, made cDNA and performed quantitative PCR for all LOXs. Interestingly, most of the LOXs were higher expressed in pulp rather than peel. Three LOXs showed a higher expression in peel: SmLOXc, SmLOXD (13-LOXs), and SmLOX5-like2 (9-LOX). Although no differences were found in quality parameters between M1 and M2, important differences were found at transcript level. The LOX genes were higher expressed in M1, in contrast to M2, which showed a general decline of gene expression probably due to its advanced ripening stage. The volatile analyses of these experiments correlated to the gene expression will be discussed.

(169) Change in Glucosinolates Content during Growth and Postharvest Cold Storage of Baemoochae Plant (XBrassicoraphanus)

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Baemoochae, an intergenic breed between Kimchi cabbage (Brassica napus L.) and radish (Raphanus sativus L.) has been lately known to be an excellent functional food due to phytochemicals such as glucosinolate (GSL) and polyphenolic compounds. In order to examine distribution of GSL in Baemoochae during their growth and postharvest storage, desulfo-GSLs analysis cultivars of Baemoochae ‘BB#1’ was conducted using HPLC and UPLC-ESI-MS. Total 8 GSLs (progoitrin, glucoraphenin, glucoalyssin, gluconapin, glucobrassicinapin, glucoraphasatin, glucobrassacin, neoglucobrassicin) were identified, and glucoraphasatin was the most abundant GSL in Baemoochae in both leaves and root. The highest amount of GSL in root was detected at 10 weeks after planting in ‘BB#1’ showing 467.4 mg/100 g fresh mass. During cold storage of Baemoochae plant, a sharp decrease in GSL in leaf tissue and a rather steady decline in root tissue were manifested. There was a 30% reduction of the GSL contents in roots during 8 weeks storage, werease GSK in leaf tissue declined from 110.0 to 47.2 mg/100g fresh mass during 4 weeks. The present study suggests that utilization of Baemoochae as a vegetable crop can be determined based on their GSL content during growth and storage. The GSL distributed much higher in root tissue than leaf suggesting as economical significance. Specified Source(s) of Funding: This research was supported by iPET (Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries), Ministry of Agriculture, Food and Rural Affairs

(170) Acrylamide Content in Potato Product Is Affected By Chemical Composition in Cv. “Goun” (Solanum tuberosum L.) of Korea

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and Polyethylene terephthalate; PET). Samples were stored rinsed with tap water, centrifuged with a manual salad spinner content of cut lettuce were also determined. Cut lettuce was concentrations in the packaging containers, and the phenolic production in wounded lettuce tissues leading to enzymatic browning, phenylalanine ammonia-lyase (PAL) stimulates factors on the shelf-life of lettuce. A key enzyme in tissue browning is one of the limiting factors that induces the increase in acrylamide in processed and fried potato products. Discoloration due to enzymatic browning is one of the limiting factors on the shelf-life of lettuce. A key enzyme in tissue browning, phenylalanine ammonia-lyase (PAL) stimulates phenolics production in wounded lettuce tissues leading to enzymatic browning. In this study, effects of storage temperature and packaging materials on PAL activity and tissue browning were observed. Oxygen and carbon dioxide concentrations in the packaging containers, and the phenolic content of cut lettuce were also determined. Cut lettuce was rinsed with tap water, centrifuged with a manual salad spinner and then placed in plastic containers (Poly lactic acid; PLA and Polyethylene terephthalate; PET). Samples were stored at 10 °C and 4 °C for up to 3 or 4 days. Tissue browning was visually evaluated using a 0–3 hedonic scale: 0, none; 1, light; 2, moderate; and 3, severe browning. The samples stored at 10 °C for 3 days in both PET and PLA, the enzyme activity reached its maximum level after 21 h and then gradually decreased, while slight tissue browning was observed on the final day of the storage. However, the samples stored at 4 °C for 3 days, no tissue browning was found in any of the samples stored either in PLA or PET containers. Compared with the samples stored at 10 °C, PAL activity increased and remained at a higher level in the samples stored at 4 °C for 4 days. No major differences were found in the enzyme activity between the samples stored in PET and PLA containers at 4 °C. Low temperature storage has led to the unexpectedly higher levels of the enzyme activity. However, slight browning was found in the samples stored in PET and PLA only on the final day of the storage. The oxygen concentration in PET container remained 19.5% and no major changes were found in PLA container during storage. The CO2 concentration in PET container increased markedly (1.7%), while the CO2 level in PLA container increased only up to 0.4% and then decreased. Total phenolics increased in both storage-samples at both temperatures, while a slight decrease in phenolics was detected on the final day of the storage at 10 °C. The results conclude that tissue browning can be delayed when cut lettuce was stored at 4 °C, in spite of the higher level of PAL activity and phenolic content.

**Specified Source(s) of Funding:** Ryukoku University

(172) Ethylene Treatments Resulted in Accumulation of Anthocyanins in Fortress Russet Cultivar

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Plants may synthesize secondary metabolites when they are exposed to pre- and postharvest abiotic stresses. These changes can lead to numerous quality problems in fruits and vegetables. Anthocyanin content of potato tubers is an important trait that is attracting increasing attention in some specialty cultivars, but in some russets it is considered a negative quality trait. Stress may have an impact on phytochemical accumulation, as in the case of temperature and light exposure influence on anthocyanin accumulation in certain potato cultivars. In this study, we treated Fortress Russet tubers with the phytohormone, ethylene, at two concentrations for three weeks. Tubers treated with 5 PPM ethylene expressed more anthocyanin pigment compared to 1 PPM and a control. We also tested different temperature treatments to reduce anthocyanin levels in tubers expressing pink flesh. Tubers maintained at 55 °F showed reduced anthocyanin levels compared to tubers kept at 38 or 45 °F. These results suggest that Fortress Russet tubers accumulate anthocyanin pigments when exposed to postharvest abiotic stresses. Postharvest treatments such as storage temperature may mitigate pink flesh resulting.

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**Poster Presentations**

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Variation in the reducing sugar content between cv. Atlantic and cv. Goun was not significant although it was significantly different in accordance with year. Increased reducing sugar content was observed at 120 days after planting. So, it is considered that late harvest (i.e. 120 days after planting) could adversely affect the processing quality. The asparagine content of raw material in cv. Goun was observed to be lesser compared to cv. Atlantic. But it was not significant according to the environment of cultivation year. Asparagine is a kind of free amino acid that is the richest amino acid among the free amino acids present in potato tubers. The order of major free amino acids content is: asparagine > glutamic acid > arginine > aspartic acid > valine. Asparagine is known as a precursor of acrylamide. Although there was no significant difference in acrylamide content between cv. Atlantic and cv. Goun, it was comparatively lower in cv. Goun compared to cv. Atlantic. It is considered that existence itself of asparagine is a critical factor in determining the acrylamide content. Variation in the acrylamide content in 2 years was similar to that of reducing sugar content in potato tuber. Positive correlation was also observed between acrylamide content and reducing sugar (Pearson’s $r = 0.676$, $P \leq 0.0001$). Hence, our study suggests that increase in the reducing sugar content in raw potato is the major factor that induces the increase in acrylamide in processed and fried potato products.

**Specified Source(s) of Funding:** Ryukoku University

(171) Storage Temperature Affects Phenylalanine Ammonia-Lyase (PAL) Activity and Tissue Browning in Fresh-cut Lettuce

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Discoloration due to enzymatic browning is one of the limiting factors on the shelf-life of lettuce. A key enzyme in tissue browning, phenylalanine ammonia-lyase (PAL) stimulates phenolics production in wounded lettuce tissues leading to enzymatic browning. In this study, effects of storage temperature and packaging materials on PAL activity and tissue browning in fresh-cut lettuce were studied. Oxygen and carbon dioxide concentrations in the packaging containers, and the phenolic content of cut lettuce were also determined. Cut lettuce was rinsed with tap water, centrifuged with a manual salad spinner and then placed in plastic containers (Poly lactic acid; PLA and Polyethylene terephthalate; PET). Samples were stored at 10 °C and 4 °C for up to 3 or 4 days. Tissue browning was visually evaluated using a 0–3 hedonic scale: 0, none; 1, light; 2, moderate; and 3, severe browning. The samples stored at 10 °C for 3 days in both PET and PLA, the enzyme activity reached its maximum level after 21 h and then gradually decreased, while slight tissue browning was observed on the final day of the storage. However, the samples stored at 4 °C for 3 days, no tissue browning was found in any of the samples stored either in PLA or PET containers. Compared with the samples stored at 10 °C, PAL activity increased and remained at a higher level in the samples stored at 4 °C for 4 days. No major differences were found in the enzyme activity between the samples stored in PET and PLA containers at 4 °C. Low temperature storage has led to the unexpectedly higher levels of the enzyme activity. However, slight browning was found in the samples stored in PET and PLA only on the final day of the storage. The oxygen concentration in PET container remained 19.5% and no major changes were found in PLA container during storage. The CO2 concentration in PET container increased markedly (1.7%), while the CO2 level in PLA container increased only up to 0.4% and then decreased. Total phenolics increased in both storage-samples at both temperatures, while a slight decrease in phenolics was detected on the final day of the storage at 10 °C. The results conclude that tissue browning can be delayed when cut lettuce was stored at 4 °C, in spite of the higher level of PAL activity and phenolic content.

An asterisk (*) following a name indicates the presenting author.
Watermelon flesh firmness is expected to be a minimum of 12 N at harvest when measured in the locale area in order to withstand shipment and reduce drip loss. Firm fleshed watermelon cultivars are now available and grafting helps further enhance firmness. Measurement of firmness is usually done with a hand held gauge but this requires the same person to take all readings, and even then has limited accuracy. Stationary devices engaging a mechanized lever for readings have had demonstrated improvement in accuracy and better precision among those doing the testing. One of the other challenges in testing watermelon firmness is the size of the fruit. Most commercial firmness testers have plates designed for much smaller fruit. And, since most watermelon testing is done under field or packing shed conditions, a firmness tester has to be robust enough to withstand juice, dirt, and jostling. We designed a firmness tester using a Dremel stand, a Wagner FDX force gauge, and a thick cutting board (1.6 cm).

The force gauge was mounted on the Dremel stand which was set up as a cross bar mounted on aluminum steel tubing, and a slot was cut into the cutting board to allow for balance of the rounded rind. The tubing was set far enough apart to allow the watermelon to slide between tubing for precise alignment with locular or heart tissue and the lever that comes with the Dremel drill stand was used to lower the gauge. The FDX force gauge, equipped with a 25 lb module and a 11 mm flat compression probe, is digital and results can be downloaded directly to a computer. This system cost about $1,000 in parts to build and proved to be both operator neutral and less tiring than a handheld gauge. It was tested on seedless watermelon (10 to 15 kg size) grafted to ‘Carnivor’ rootstock and held for 0 to 2 weeks in storage at 13 °C. Firmness of locule tissue was slightly firmer in grafted fruit (16.8 N) than not grafted (12.4 N) after 2 weeks, and much firmer in heart tissue (32 N vs. 18 N) in grafted and not grafted fruit, respectively. This tester provides a means of easily collecting firmness data with more precision and accuracy and may help differentiate the physiological mechanisms that improve watermelon flesh firmness and rootstock and scion influences.

The essential oils of clove bud, thyme, and cinnamon, emulsified with gum arabic, were previously found to effectively inhibit microbiological growth at concentrations of 0.2 to 0.5% EO and to disperse in water. Organically grown firm ripe ‘Mountain Magic’ tomatoes were harvested in Knoxville TN and Waynesville NC in 2015 and washed with chlorine (200 ppm), water, clove bud oil (CBO) (0.2 and 0.5%), thyme oil (0.2 and 0.5%) or citrox (0.5 and 0.75%, an organic bioflavonoid/fruit aid blend). Tomatoes were held at 15 °C for 14 days and subsampled at 0, 7, and 14 days for weight loss, appearance, and composition. Weight loss was 0.3 and 0.5% after 7 and 14 days for all treatments. After 14 days, tomatoes treated with CBO or chlorine were borderline marketable. Those treated with water had slight flaws and those treated with citrox or thyme oil were intermediate in appearance. Fruit composition changed over storage time, with pH and lycopene content increasing. Total lycopene (78-83 mg/100 g fwt) was highest at all storage days for TO (0.2%). In contrast, soluble solids content was highest for the chlorine treated tomatoes after 0 and 7 days (6.6%) and lowest at 14 days storage. Total phenolic content of tomatoes decreased over storage for most treatments and increased slightly in tomatoes treated with thyme oil (400 to 440 mg/kg fwt). Our results indicate that ‘Mountain Magic’ tomatoes treated with essential oils generally had slight changes compared to water or chlorine. Thyme oil may have slightly stimulated compositional changes, as indicated by increases in total lycopene and phenol contents.

**Poster Session—Tropical Horticultural Crops**

(273) Pitahaya or Dragon Fruit (Hylocereus spp.) Varieties: Evaluation, Morphological Description, and Genetic Characterization

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**Poster Presentations**

(173) Development of a Firmness Tester Designed for Large Watermelon

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Jack Lotito
North Carolina State University, Kannapolis, NC

Richard Hassell
Clemson University, Charleston, SC

(174) Essential Oil Disinfectant on Appearance and Composition of Organically Grown Tomatoes

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Jeanine Davis
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Poster Presentations

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Hylocereus (Berger) Britton and Rose and Selenicereus (Berger) Britton and Rose are two genera of a vining cactus commonly named pitahaya (in America and Europe) and/or Dragon Fruit (in Asia). The plant, native to tropical America, adapts very well to various climatic conditions in its native habitat, where it grows at nearly sea level in the arid coastal plains of the Pacific Coast and in more humid, cloud forests conditions at higher elevations. Pitahaya produces an edible fruit that has gained popularity as an exotic fruit in many countries in Asia, America and Europe, and this popularity has increased consumer demand for the fruit. The plant has tolerance to drought and adapts well to dry, hot environments where sub-tropical fruit cannot be grown and this has generated enormous interest among backyard growers and commercial producers in Southern California. There is uncertainty among named varieties and significant taxonomic confusion about the species within these genera, which limits the growth and expansion of this industry. Twenty varieties of pitahaya were planted in a randomized complete-block design at the University of California (UC) South Coast Research and Extension Center (SCREC) in Irvine, California to assess their adaptation and performance in field grown conditions. A selected set of these varieties were planted at UC Hansen Agricultural Center (HAREC) in Santa Paula and at the University of California, Riverside Coachella Valley Research Station (CVRS) to expand the geographic scope of the research and further screen these varieties in different, harsher environments. In addition, a germplasm collection was curated at the SCREC and 54 accessions were grown for observation. Results from our project show that pitahaya or dragon adapts well to local microclimates and is a viable crop alternative for small-scale agricultural producers California. In addition to performance data, our study also helped develop detailed morphological description of all pitahaya cultivars planted. Finally, amplified fragment length polymorphism (AFLP) were used to genotype 230 accessions of pitahaya to determine redundancy among commonly named varieties and to assess the diversity of the collection. Some differently named varieties were identical based on our analysis, but there was also genotypic diversity within putatively named varieties. The results of this study will help growers and researchers to choose genetically distinct or genetically similar accessions from the germplasm collection or from nursery operations in order to investigate how different varieties and/or accessions perform in their growing regions.

Specified Source(s) of Funding: UC Hansen Trust

(275) Flowering and Fruiting Data for Purple-fruited Pitanga (Eugenia uniflora L.) Grown in Hawaii at the Kona Experiment Station Aid in Selection of Potential New Varieties
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Thousands of species of plants produce various industrial, edible or medicinal components, but fewer than 100 plant species yield almost all of the food products available on a commercial scale worldwide. Pitanga, however, is not a newly discovered fruit, although its commercial potential has not been widely developed except in its native Brazil. European explorers discovered the pitanga in South America several centuries ago and spread red-fruited seedlings throughout the tropics worldwide. Introduced to Hawaii in the nineteenth century, fruits have long been popular in farmers’ markets and are in demand by chefs and processors. Interest in the crop has expanded rather recently because of the availability of purple-fruited, high-antioxidant, better-tasting, sweeter fruits. Recently, several purple-fruited selections were introduced to growers in Brazil. In Florida, the tasty and prolific ‘Zill Dark’ purple-fruited cultivar has been available for many years and is the parent plant of the large seedling field of pitanga planted at the Kona Experiment Station. Factors that have limited further development of purple-fruited pitanga include considerable variation among seedlings and their fruits, difficulty in clonal propagation and lack of recognizably superior cultivars. The planting at Kona has 137 seedlings from a ‘Zill Dark’ self-crossing and 20 grafted plants of ‘Zill Dark’. As the planting has matured, the plants have been evaluated for pest and disease problems and fertilizer and water requirements. Fruits from individual plants have been evaluated for antioxidant content, flavor, fruit weight, seed size and postharvest quality. From 2013 to 2015, all individual plants were evaluated weekly for presence of flowers and/or fruits in various stages of development. Analysis of the flower and fruit data collected may allow selection of early- and late-bearing plants so that the fruiting season for the crop may be substantially increased. Fruit characteristics of early- and late-bearing plants are being evaluated further.

(276) Use of Reflective Mulch to Enhance Light Interception of Understory Leaves of Musa sp. ‘Mysore’ Bananas
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Specified Source(s) of Funding: UC Hansen Trust

(275) Flowering and Fruiting Data for Purple-fruited Pitanga (Eugenia uniflora L.) Grown in Hawaii at the Kona Experiment Station Aid in Selection of Potential New Varieties
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Thousands of species of plants produce various industrial, edible or medicinal components, but fewer than 100 plant species yield almost all of the food products available on a commercial scale worldwide. Pitanga, however, is not a newly discovered fruit, although its commercial potential has not been widely developed except in its native Brazil. European explorers discovered the pitanga in South America several centuries ago and spread red-fruited seedlings throughout the tropics worldwide. Introduced to Hawaii in the nineteenth century, fruits have long been popular in farmers’ markets and are in demand by chefs and processors. Interest in the crop has expanded rather recently because of the availability of purple-fruited, high-antioxidant, better-tasting, sweeter fruits. Recently, several purple-fruited selections were introduced to growers in Brazil. In Florida, the tasty and prolific ‘Zill Dark’ purple-fruited cultivar has been available for many years and is the parent plant of the large seedling field of pitanga planted at the Kona Experiment Station. Factors that have limited further development of purple-fruited pitanga include considerable variation among seedlings and their fruits, difficulty in clonal propagation and lack of recognizably superior cultivars. The planting at Kona has 137 seedlings from a ‘Zill Dark’ self-crossing and 20 grafted plants of ‘Zill Dark’. As the planting has matured, the plants have been evaluated for pest and disease problems and fertilizer and water requirements. Fruits from individual plants have been evaluated for antioxidant content, flavor, fruit weight, seed size and postharvest quality. From 2013 to 2015, all individual plants were evaluated weekly for presence of flowers and/or fruits in various stages of development. Analysis of the flower and fruit data collected may allow selection of early- and late-bearing plants so that the fruiting season for the crop may be substantially increased. Fruit characteristics of early- and late-bearing plants are being evaluated further.

(276) Use of Reflective Mulch to Enhance Light Interception of Understory Leaves of Musa sp. ‘Mysore’ Bananas
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Specified Source(s) of Funding: UC Hansen Trust

(275) Flowering and Fruiting Data for Purple-fruited Pitanga (Eugenia uniflora L.) Grown in Hawaii at the Kona Experiment Station Aid in Selection of Potential New Varieties
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Thousands of species of plants produce various industrial, edible or medicinal components, but fewer than 100 plant species yield almost all of the food products available on a commercial scale worldwide. Pitanga, however, is not a newly discovered fruit, although its commercial potential has not been widely developed except in its native Brazil. European explorers discovered the pitanga in South America several centuries ago and spread red-fruited seedlings throughout the tropics worldwide. Introduced to Hawaii in the nineteenth century, fruits have long been popular in farmers’ markets and are in demand by chefs and processors. Interest in the crop has expanded rather recently because of the availability of purple-fruited, high-antioxidant, better-tasting, sweeter fruits. Recently, several purple-fruited selections were introduced to growers in Brazil. In Florida, the tasty and prolific ‘Zill Dark’ purple-fruited cultivar has been available for many years and is the parent plant of the large seedling field of pitanga planted at the Kona Experiment Station. Factors that have limited further development of purple-fruited pitanga include considerable variation among seedlings and their fruits, difficulty in clonal propagation and lack of recognizably superior cultivars. The planting at Kona has 137 seedlings from a ‘Zill Dark’ self-crossing and 20 grafted plants of ‘Zill Dark’. As the planting has matured, the plants have been evaluated for pest and disease problems and fertilizer and water requirements. Fruits from individual plants have been evaluated for antioxidant content, flavor, fruit weight, seed size and postharvest quality. From 2013 to 2015, all individual plants were evaluated weekly for presence of flowers and/or fruits in various stages of development. Analysis of the flower and fruit data collected may allow selection of early- and late-bearing plants so that the fruiting season for the crop may be substantially increased. Fruit characteristics of early- and late-bearing plants are being evaluated further.
Posters Presentations

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Bananas are typically characterized as having long production cycles (>9 months) and initiate flowering seemingly without regard to temperature or light. Growing seasons in the subtropics are even more protracted due to cooler temperatures. To aid in sustainable banana production in the Gulf coast of Alabama, innovative production practices should be sought that encourage shortened production cycles that lend themselves to an annual cropping system such as in the case of tree fruit such as peaches, apples and pears. The most photosynthetically active leaves of banana plants are leaves 2 through leaf 5. Photosynthesis is reduced after leaf 6 and leaves further down the plant profile begin to senesce, which is likely due to shading. The objective of this study is to determine if enhanced lighting from reflective materials can shorten the production cycle of bananas. Reflective mulches and fabrics have been used to enhance the light environment to increase photosynthesis and hence yield and earliness of harvest. In this study white fabric and silver reflective film panels (7.3 m x 2.0 m) were placed on either side of Musa sp. (AAB) ‘Mysore’ planted in groups of three forming an experimental unit. The experiment followed a completely randomized block design with six replications. A treatment that received no reflective mulch or fabric was included in the study as a control. Phenological/physiological data were collected periodically. Interaction between reflective mulch treatment and days from transplanting (DAP) (width >10 cm) significantly affected pseudostem length, pseudostem circumference, height:circumference ratio (HCR) leaf area, number of leaves present (NLP) and leaf emergence rate. In terms of bunch yield and bunch characteristics, reflective fabric consistently produced higher values then the control. Silver film and white fabric mulches treatments significantly increase light at 1 m above ground but did not significantly increase rate of net photosynthesis. Silver reflective mulch produced bunch yield that was 26% higher than the control while white reflective mulch produced bunch yield that were 15% higher than the control. Silver and white reflective mulch treatments yielded 11% and 21% respectively above bananas of the control treatment, but differences were not significant. White reflective fabric significantly reduced number of days to flower emergence (216 c) compared to both silver reflective (247 a) and control treatment (221 b). Reflective materials show potential to reduce cropping cycle of bananas to increase sustainability of this production system.

Specified Source(s) of Funding: Alabama Fruit, Nut and Vegetable Industries

(277) Sensor-based Irrigation in Different Sweet Pepper Varieties in the U.S. Virgin Islands

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Sweet peppers are widely produced in the Caribbean islands. Farmers usually water the plants without using the proper water management techniques. Soil-based monitoring systems can be used to improve water use efficiency and save water resources. Our study evaluated the use of low-cost open-source equipment to control irrigation and the potential yield of sweet pepper varieties in the U.S. Virgin Islands. We tested two soil volumetric water contents (VWC) to trigger irrigation (0.32 and 0.42 m3/m3) and six sweet pepper varieties (Aristotle, Declaration, Intruder, Jupiter, Colossal, and Vanguard), in a CRD with three replications, totaling 36 experimental units. Plants were transplanted into a Sion clay soil and fertigated using 113 kg N/ha of a 20–20–20 soluble fertilizer (200 mg/L N concentration). We assembled three independent and fully automated irrigation systems using a Mega 2560 board (Arduino), a logging shield (Adafruit), twelve 10HS soil moisture sensors (Decagon Devices), two 5-VDC 8-module relay drivers (SainSmart) and twelve 24-VAC 2.54-cm solenoid valves (RainBird) connected to a 12/24-VDC 500-VA 31EJ02 transformer (Dayton). The power line to fed the solenoids was protected with a 3400-J 51110-SRG surge protector (Leviton). When the soil VWC dropped below the thresholds, the irrigation was turned on for 1 min. The irrigation was installed using a manifold built with 2.54-cm PVC pipes, one solenoid valve and 1.9-cm polyethylene tubing with 4-L/hr drip emitters. When the soil VWC dropped below the thresholds, the irrigation was turned on for 1 min. The soil moisture sensors malfunctioned due to a defective internal part, not controlling the irrigation properly. Irrigations were turned on manually every other day. The two VWC treatments were averaged, resulting in six replications per variety. Total yield ranged from 13,514 (‘Declaration’) to 16,940 kg/ha (‘Vanguard’). However, the total and marketable yield did not differ among varieties ($P > 0.05$). Anthocyanin at 67 days after transplanting (DAP) was higher on ‘Colossal’ (18.56 ACI) compared to ‘Vanguard’ and ‘Declaration’ (12 ACI on average) ($P = 0.0126$). Leaf chlorophyll and fruit weight, width, length and sugar content at 95 DAP were not significantly different ($P > 0.05$). Fruit hardness was higher on ‘Intruder’ and ‘Jupiter’ (1.2 kgf) and lower on ‘Colossal’ and ‘Vanguard’ (0.96 kgf) ($P = 0.0012$). Based on our results, fully functional sensors are necessary to control irrigation properly. All six varieties presented high yield, being suitable for cultivation in the U.S. Virgin Islands.

Specified Source(s) of Funding: Funding for this research was provided by USDA-NIFA-Hatch Funds

(278) Greenhouse Production of Slicing Cucumbers in the U.S. Virgin Islands

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Cucumber is one of the major vegetables in greenhouse production. Little information is available regarding the cultivation of cucumbers in closed environment in the U.S. Virgin Islands. Our study evaluated the production of slicing cucumbers in greenhouse under different substrate volumetric water contents (VWC) applied using low-cost open-source microcontrollers. We tested four cucumber varieties (‘Boa’, ‘Bomber’, ‘Corinto’ and ‘Summer Dance’) and three substrate VWCs to trigger irrigation (0.24, 0.36 and 0.48 m³/m³), on a split-plot CRD and three replications. Plants were transplanted into 9.45-L pots with Pro-Mix BX Mycorrhizae: perlite substrate (70%: 30%), trained on a vertical plastic line, and fertigated with calcium nitrate (150 and 140 mg/L Ca and N) and 10—30—20 peat-lite plant starter fertilizer (30 mg/L N). We assembled two independent and fully automated irrigation systems using a Mega 2560 board (Arduino), a logging shield (Adafruit), eighteen 10HS soil moisture sensors (Decagon), three 5-VDC 8-module relay drivers (SainSmart) and eighteen 24-VAC 2.54-cm solenoid valves (RainBird) connected to a 12/24-VDC 500-VA 31EJ02 transformer (Dayton). The power line was protected with a 3400-J 51110-SRG surge protector (Leviton). The system was powered using a 20-W Infinium solar panel (ML Solar) connected to a 12/24-VDC 10-A 1210RN solar charge controller (EPSolar) and two 12-VDC 7.2-Ah rechargeable batteries (Yuasa). Irrigation was installed using a manifold built with 2.54-cm PVC pipes, one solenoid valve and 1.9-cm polyethylene tubing with 4-L/h drip emitters connected to one O-ring tubing per plant. When the soil VWC dropped below the thresholds, irrigation was turned on for 1 min. The soil moisture sensors malfunctioned due to a defective internal part, not controlling the irrigation properly. Irrigation was controlled manually every other day. The three VWC treatments were averaged, resulting in nine replications per variety. ‘Corinto’ (22,436) and ‘Boa’ (20,000 kg/ha) total yield were higher than ‘Summer Dance’ (10,604) and ‘Mountie’ (10,435 kg/ha) (P = 0.0001). Marketable yield was respectively 85%, 91%, 63% and 40% of the total yield (P < 0.0001). Total number of fruits per plant were 9.6 for ‘Corinto’, 7.1 for ‘Boa’, 4.7 for ‘Mountie’ and 3.8 for ‘Summer Dance’ (P < 0.0001). Fruit width, hardness and sugar content were not significantly different (P > 0.05). Fruits were shorter on ‘Boa’ (18.7 cm) and ‘Corinto’ (19.7 cm) compared to ‘Mountie’ (24.2 cm) and ‘Summer Dance’ (25.7 cm) (P = 0.0180). Based on our results, fully functional sensors are necessary to control irrigation properly. ‘Corinto’ and ‘Boa’ are the recommended varieties for greenhouse cultivation in the U.S. Virgin Islands.

Specified Source(s) of Funding: Funding for this research was provided by USDA-NIFA-Hatch Funds

(279) Effect of Strand Thinning on Yield and Fruit Quality of Egyptian Dry Date Palm (Phoenix dactylifera L.) cv. Sultani
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Strand thinning is one of the common cultural practices used by Egyptian date palm farmers to reduce the incidence of alternate bearing, increase overwring, reduce the compactness of bunches, and improve yield and fruit quality. Five treatments of strand thinning were carried out; 15% strand thinning on the day of pollination, 30% strand thinning on the day of pollination, 15% strand thinning 15 days after pollination, 30% strand thinning 15 days after pollination, and the control. Compared to the control, all thinning treatments improved fruit weight, esh weight, and tannin, vitamin C, and total and reducing sugars concentrations. Thinning 30% of strands 15 days after pollination resulted in the best physical and chemical characteristics compared to other thinning treatments.

Specified Source(s) of Funding: Scientific Research Center, College of Food and Agricultural Sciences, King Saud University, Kingdom of Saudi Arabia

(280) Yield Performance of New Macadamia Nut Selections in Kona, Hawaii
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Macadamia nut (Macadamia integrifolia) is one of the most important agricultural commodities for the state of Hawaii with over 18,000 acres in production and a farm value of $35 million. Successful production of macadamia in Hawaii is related to the research and identification of high yielding selections that produce kernels with superior qualities. At least 13 commercial cultivars have been developed in Hawaii, but seven of these dominate the commercial plantings of macadamia in Hawaii. Although other selections were identified as promising for superior kernel quality, tree shape, and pest resistance, none of these have been released to the public. A field trial was established at the University of Hawaii Kainaliu Research Station in Kona (390 m elevation), in July 2001 to evaluate seven selections of macadamia nut based on kernel quality performance, including two commercially released selections ‘800’ and ‘344’. Yield data were collected from 2010 to 2014 and quality data collection began in November 2015. Year was significant for yield (kg/tree) (P < 0.001) with yields increasing with tree age. Selection also significantly affected yields (P < 0.001), however there was no year by selection interaction. The commercial selection ‘800’ yielded higher than four of the other selections (‘862’, ‘896’, ‘932’, and ‘344’) with average annual yields of 72 kg/tree. Yields among the remaining selections (‘879’ and ‘344’) were not significantly different from the other selections. The lowest yields were observed in ‘932’ with average annual yields of 36.6 kg/tree. Initial quality data supports continued evaluation of these selections for the
quality characteristics. Kernel weights of the selections ranged from 2.8 to 3.37 g, within the recommended range of 2.5-3.2 g. Kernel recovery also fell within the acceptable range of 38-48% for most of the selections. One exception was selection ‘900’, which was very large (11.9 g nut weight) compared to the other selections (average of 8.1 g). The kernel recovery rate of ‘900’ was 28% but the kernel weight was 3.37 g, suggesting an unusually thick shell on this selection. The majority of the new selections yielded similarly to the commercial selections of ‘344’ and ‘800’. While initial quality analysis suggests that many of these selections are of high quality with desirable traits, further quality analysis is needed to determine stability over time and space. Therefore, these selections should be evaluated in multiple locations to determine yield performance and quality under varying environmental conditions in Hawaii for release into the market.

(281) Yield and Fruit Quality Traits of Dragon Fruit Lines and Cultivars Grown in Puerto Rico

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Dragon fruit or pitahaya (*Hylocereus undatus* and *Selenicereus megalanthus*) is a member of the Cactaceae family and native to the tropical forest regions of Mexico, Central, and South America. The fruit was practically unknown 15 years ago but it occupies a growing niche in Europe’s exotic fruit market. The crop adapts to different ecological conditions ranging from very dry regions to wet ones receiving over 3500 mm/year of rainfall. United States commercial production of dragon fruit occurs mainly in Southern California, Hawaii, and Puerto Rico. As growers learn more about this crop and how productive it can be, the acreage planted will increase significantly. Twelve pitahaya lines and cultivars grown on an Oxisol soil were evaluated for four years under intensive management at Isabela, PR. There were significant differences in number and weight of fruit per hectare between years. Lines and cultivars exhibited an increase in fruit number and yield from 2010 to 2013. This response was expected as plants increased in age. There were significant differences among lines and cultivars for number of fruit and yield per hectare. Lines N97-17, NOI-14, N97-15, and N97-22 produced significantly more fruit averaging 50,553 fruit/ha. Significantly higher fruit yield was obtained by lines N97-22, NOI-13, NOI-14, N97-17, and N97-15 averaging 15,266 kg/ha. Cultivar Cosmic Charlie had the lowest fruit yield averaging only 31 kg/ha. Individual fruit weight was significantly higher in line N97-20 with fruit weight averaging 488 g. Lines NOI-16, N97-15, N97-18 had significantly higher fruit soluble solids (°Brix) than other cultivars averaging 17.4%. Some of the lines used in this study have shown horticultural potential and may serve as new selections for growers in the U.S. Continental and Insular areas. Research is still ongoing to collect additional data on yield as well as reaction to insect and disease pressure.

(328) Effect of Drainage Ratio in Nutrient Supply on Growth and Yield of Paprika (*Capsicum annum* L.) in Long-term Recycling Hydroponic Cultivation in South Korea

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Due to the global climate change, sustainable agriculture has become necessary. Regarding to paprika (*Capsicum annum* L.) cultivation, use of circulating hydroponic system can contribute to prevent water pollution and reduce waste water. Even though many of paprika farms in Korea install the circulating hydroponic system, few farms actually use it. This is due to the fact that there is no useful data that can be applied for long-term paprika cultivation under circulating hydroponic system. This study, therefore, was conducted to provide practical information to paprika farms with circulating hydroponic system by analyzing the effect of drainage ratio in water supply on the growth and yield during the entire growth period of paprika. This experiment was comprised of four treatments with different drainage ratios in water supply; 100% nutrient solution (NS), 80% nutrient solution + 20% drainage (D), 70% NS + 30% D and 50% NS + 50% D. The experiment was performed for 35 weeks, from spring to winter in 2015. Based on the growth stages of paprika, growth characteristics were investigated every week, and each investigation was categorized from group 1 to group 5. The results of this study showed that leaf area and total yield of paprika were reduced whereas flowering position was prolonged as the HWS ratio increased. There, however, was no significant difference in total yield from group 3 to group 5 as well as between treatment of 70% NS + 30% D and 80% NS + 20% D. In addition, total yield in 70% NS+30% D was 92% of that in 100% NS. These results show that growth and yield of paprika are not affected by use of recycled nutrients during long-term hydroponic cultivation. These results will be introduced to paprika farms, which would contribute to rapid expansion of using the circulating hydroponics system in Korea.

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(329) Assessments of Flavor and Health-associated Compounds and Taste Panel Preferences in Watermelon

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Many consumers select watermelons (*Citrullus lanatus*), based on outward appearance or a prior experience consuming and enjoying a particular variety. Evaluations of most varieties suggest positive correlations between sugar and organic acid content, while pectin, fiber, and juice volume are generally negatively correlated. Additionally, watermelons have been shown to contain significant amounts of the carotenoid pigment lycopene. To test flavor and health compounds as well overall consumer likeability a trial was conducted. Ten varieties were selected from a larger variety trial grown using plastic mulch and drip irrigation in Tifton, GA, in Spring 2015. Ripe fruit were selected from each of three replicated plots in the field and analyzed for soluble solids content (SSC), titratable acidity, pH, simple sugars, organic acids, and total anthocyanins. In addition a taste panel was conducted with 14 participants to judge overall likeability. There were significant differences in SSC and total sugars, though the varieties with the highest SSC were not necessarily those with the highest total sugar content. The varieties Joy Ride and Summer Breeze had the highest total sugars, while 7187 HQ had the highest SSC concentration. This suggests that total SSC, typically measured using a refractometer in variety trials may not be necessarily reflective of the total sugar content in watermelons. Total anthocyanin concentrations did not differ significantly among varieties, ranging from 6 to 11.8 mg·L⁻¹ of cyanidin-3-glucoside equivalents in UAWX11379 and SV0241, respectively. Though not significant, SSC and total sugar content were positively correlated with taste panel likeability scores, while titratable acidity was negatively correlated to taste panel preferences. This information will be used by growers and seed companies to select and grow varieties with superior production attributes, as well as qualities important to the consumer.

(330) Abiotic and Biotic Factors Influencing Quality and Quantity within Brassicaceae Using Various Planting Methods in High Tunnels

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To increase consumer interest in year-round locally grown organic produce, farmers are exploring high tunnel production agriculture. With the extension of the growing season, high tunnels may improve productivity and increase profitability for farmers. This research examines optimizing the growth of one *Brassica* species, Chinese cabbage or Pak Choy, in the interior of high tunnels. The crops were organically grown under similar conditions utilizing municipal water with T-tape irrigation, and included two variables. The first variable explored direct sow planting versus float bed planting, while the second variable observed succession planting versus single planting harvest. The research was replicated in all four high tunnels, where each planting session was introduced into the project through random selection. This research will quantify the yield of the crops, along with testing the microbial quality of the high tunnel soil and municipal water. The harvested produce will also be tested for contamination. An additional factor that was observed during this project included temperature profiles inside the high tunnels, outside temperatures and soil temperatures. By verifying high tunnel production as an effective source for plant growth beyond the initial harvest period, farmers will have access to successful methods of growing *Brassica* crops.

Specified Source(s) of Funding: HBCU Graduate Funds

(331) Influence of Heating Nutrient Solution on Greenhouse-grown Hydroponic Lettuce

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Hydroponic lettuce production is increasingly popular in the southeastern United States. In order to compete with field-grown lettuce, production costs of greenhouse-grown lettuce should be decreased. A potential way to decrease production costs is to reduce energy usage by heating nutrient solutions instead of air. An experiment was conducted from 24 Feb. 2016, to 4 Apr. 2016, in a heated greenhouse to determine effects of heating nutrient solutions lettuce (*Lactuca sativa* L. ‘Rex’) grown in deep water culture. Lettuce seeds were germinated and grown for two weeks in OASIS® cubes (2.54 cm x 3.18 cm x 3.81 cm). Seedlings were fertilized with 50 mg·L⁻¹ N from Gramp’s Original 8–15–36, 100 mg·L⁻¹ N from calcium nitrate (15.5–0–0), and 40 mg·L⁻¹ Mg from magnesium sulfate (10% Mg) before

An asterisk (*) following a name indicates the presenting author.
being transplanted to deep water culture containing the same nutrient solution mixture. Seedlings were randomly assigned to one of twelve Styrofoam boards (2.54 cm thick), which were floated on nutrient solutions contained in one of twelve, 42.5-L plastic boxes (AKRO-MILS® Multi-load Tote). Nutrient solutions were either unheated (control), continuously heated to a target temperature of 16 °C, or continuously heated to a target temperature of 22 °C using aquarium heaters (Hailea® Aquarium Heater 200w). Outdoor and greenhouse air temperatures, along with nutrient solution temperatures, were recorded hourly. The experiment was a completely randomized design, with four replications per nutrient solution temperature treatment and was repeated three times. Data were pooled across each repeated experiment and were subjected to analysis of variance in JMP Pro 12 and means were separated using Tukey’s HSD (α = 0.05). Greenhouse daytime and nighttime air temperatures averaged 25.9 °C and 17.6 °C, respectively. Nutrient solution temperatures for the unheated control, target 16 °C and target 22 °C averaged 20.4 °C, 21.8 °C, and 23.2 °C, respectively. Shoot fresh weight was highest when nutrient solution was heated to 22 °C (68.8 g), but was not significantly different between 16 °C and unheated control treatments (53.4 and 58.3, respectively). Root fresh weight was also highest when nutrient solution was heated to 22 °C (14.8 g), but was not different between 16 °C and unheated control treatments (12.1 and 11.9 g, respectively). Heating greenhouse lettuce nutrient solutions during production may decrease energy costs and production times, thereby improving potential profits.

(332) Local Lettuce: Heat-tolerant Romaine Cultivars and Vermicompost Soil Amendment to Increase Sustainability in the Mid-Atlantic

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The ever-growing sustainable agriculture movement demands novel solutions. Local production is one proven approach. Lettuce (Lactuca sativa) is a cool weather crop produced primarily in California and Arizona; identifying heat-tolerant cultivars for season extension would increase competitiveness of lettuce production in the Mid-Atlantic. Vermicomposts, composts produced using earthworms, are soil amendments with the potential to increase yield and quality of lettuce crop while improving sustainability by recycling organic wastes. We are testing an innovative strategy for local lettuce production utilizing heat tolerant romaine lettuce cultivars grown with a series of locally produced vermicomposts. Preliminary trials began in 2012, replicated field trials began in 2013, and a greenhouse component was added in 2015. Results indicate that some cultivars may be suitable for grower trials during the summer season in the Mid-Atlantic area. Solid King was the highest yielding cultivar and may be best suited for wholesale producers. The tendency of Green Forest to bolt earlier makes it less desirable for use in warm climates. Dov and Sunbelt may be well suited to growers selling at farmers markets and CSAs where consumers are more likely to select produce with higher quality in flavor and appearance, and are less concerned with yield. Extending production beyond the cool spring and fall seasons could increase the time of the year during which lettuce is available locally, directly decreasing our local dependence on fossil fuel driven west coast market. Soil treatments were very similar statistically in terms of effects on yield and quality. However, trends indicated that vermicomposts had slightly positive effects, especially at higher rates. This is most likely due to the higher concentration and availability of N provided by this material. N mineralization rates were determined in both field and lab experiments to provide recommendations on rates and timings of these materials as compared to similar amendments. Potential benefits of this research could increase local sales, financial gain for small-scale growers, reduction of environmental impact, and the satisfaction of customer demands.

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(333) Adhesion of Biodegradable Mulches to Pie Pumpkins: A Production and Quality Consideration

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Plastic mulches provide many advantages for specialty crop production, however, disadvantages include the cost, labor and environmental issues associated with plastic mulch disposal. Although biodegradable mulches (BDMs) potentially offer an alternative to traditional plastic mulches, BDMs will only be a sustainable technology and widely adopted if they cause no harm to the environment, reduce landfill waste, and reduce overall labor costs- especially those for removal and disposal- all while providing benefits comparable to polyethylene mulch. Biodegradable mulches are designed to cover the soil during the production season, and then begin to degrade as harvest nears. A
consequence of degradation is that mulch pieces can adhere to the bottom of fruit resting on the BDM. Leaving adhered mulch on the fruit renders it unmarketable, but removing it adds extra labor costs, and growers are not likely to invest their resources in cleaning mulch from their crops. In this study, we grew pie pumpkins (Cucurbita pepo), cv. Cinnamon Girl, on five BDM treatments (BioAgri, Metabolix, Naturecycle, Organix and WeedGuardPlus) and a black plastic mulch control on raised beds in two distinct regions of the U.S. - the cool, humid Pacific Northwest in Mount Vernon, WA (15 °C average daily temperature and 83% average relative humidity) and the hot, humid Southeast in Knoxville, TN (22 °C average daily temperature and 73% average relative humidity). We counted pumpkins with mulch adhesion at harvest as one component of fruit quality; included in the count at Mount Vernon were the total number of fruit with adhered mulch (marketable plus unmarketable), and at Knoxville the count included fruit with adhered mulch that would have otherwise been marketable (marketable only). In Mount Vernon, all BDM treatments except Metabolix (1% mulch adhesion) had considerable mulch adhesion (30% to 50%). In Knoxville, Organix had 19% of otherwise marketable fruit with mulch adhesion, more than any other treatment except BioAgri with 10%. Observations in the field indicate that adhered mulch could be wiped off fruit in the early morning when fruit was damp from morning dew, yet as temperature increased throughout the day and the mulch dried on the fruit, it was no longer possible to easily remove the adhered mulch. In 2016 this study will be repeated and both sites will count and weigh fruit into categories of marketable, unmarketable, and fruit with adhered mulch (that would have been marketable otherwise).

(334) Evaluating High Tunnel and Open-field Specialty Melons for Farm-to-School Markets in West Virginia

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Cantaloupes (Cucumis melo var. reticulatis) are infected by many foliar diseases that are triggered or exacerbated by rainfall and high relative humidity. In addition, preharvest fruit cracking can significantly reduce marketable yields of some specialty melon cultivars. One potential option for growing cantaloupes and other specialty melons in West Virginia is high tunnel production. High tunnels significantly increase the air and soil temperature. In addition, the crop can be drip irrigated so there is no wet foliage for disease infection while melon quality is improved. Very few high tunnel growers in West Virginia and the Mid-Atlantic region grow specialty melons. The development of Farm-to-School markets can potentially increase the demand for late-season fruiting vegetables. The objective of this project was to evaluate 16 personal-size (≈ 2 lb.) specialty melons in high tunnel and open-field production systems in 2015. Melons were evaluated for disease tolerance, marketable yield and postharvest quality. An enterprise budget was developed for high tunnel specialty melon production. Cultivars such as ‘Sugar Cube’ and ‘Lil Loupe’ had high marketable yields across production systems and growing regions. The evaluation will continue in 2016 with an expanded evaluation of personal-size watermelons [\textit{Citrullus lanatus} (Thumb.)].

(335) Effect of Transplanting Date on the Growth of Asian Vegetables

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Demand for Asian vegetables is increasing due to a rapid increase in Asian population, health consciousness, and the desire for a variety of food. However, the cultivation information remains unknown to mainstream growers and home gardeners. With high temperature and intense solar radiation in late summer, a suitable transplanting date is of importance to successfully establish winter vegetables in West Texas regions. A field trial was conducted in El Paso, Texas to evaluate the effect of transplanting dates (20 Sept., 5 Oct., and 20 Oct.) on the growth of popular Asian vegetables ['jinhan chinese cabbage (\textit{Brassica rapa} subsp. \textit{chinensis}), kaboko chinese cabbage (\textit{Brassica rapa} subsp. \textit{pekinesis} ‘Kaboko’), pak choi chinese green (\textit{Brassica rapa} subsp. \textit{chinensis}), and shanghai bok choy (\textit{Brassica rapa} subsp. \textit{chinensis})]. One month before each transplanting date, seeds were sown in inserts containing Sunshine Redi Earth Professional Growing Mix. Seedlings were grown in a greenhouse with 1 g·L\textsuperscript{-1} Peters 15–5–15 Ca–Mg Special before transplanting. All plants were then grown in the field for eight weeks. The number of plants survived was recorded at three weeks after transplanting. Results showed that pak choi chinese green and shanghai bok choy all survived. About 60% and 30% of jinhan chinese cabbage plants died when they were transplanted on 20 Sept. and 20 Oct., respectively, whereas 50% of kaboko chinese cabbage plants died on 20 Sept. and 5 Oct. Jinhan chinese cabbage and pak choi chinese green plants flowered in the field trial indicating that they could be harvested sooner than the intended date. Transplanting date impacted the fresh weight of all tested Asian vegetables (\(P < 0.0001\)). On average, plants transplanted on 20 Oct. and 5 Oct. produced 66% to 86% and 10% to 39% less fresh weight of edible parts (leaves) than those on 20 Sept. In summary, transplanting plants on 5 Oct. could help plant establishment and subsequent growth of the above Asian vegetables in El Paso, TX. Further research is needed to confirm the effect of transplanting dates on the quality (nutrient, flavor) of Asian vegetables.

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An asterisk (*) following a name indicates the presenting author.
(336) Fluorescent and LED Lighting Effects on Hydroponically Grown ‘Winter Density’ Bibb Lettuce

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Food safety, environmental impacts, and efficient energy usage are growing concerns in horticultural production systems. Producing lettuce under artificial lighting can be a solution addressing these concerns. Light-emitting diodes (LED) offer the advantages of a narrow light spectrum, low power consumption, and little heat production. The objective of this study was to compare the effects of different light sources on the growth of compact ‘Winter Density’ Bibb lettuce in a noncirculating hydroponic system. ‘Winter Density’ Bibb lettuce seeds were started in Oasis systems. ‘Winter Density’ Bibb lettuce in a noncirculating hydroponic system. The light level was 118 µmol·m⁻²·s⁻¹ and a photoperiod of 16 h. After 10 days, half of the plants in the containers were moved under T5 high output fluorescent lighting for 10 more days. The light level was 118 µmol·m⁻²·s⁻¹ and the photoperiod 16 h. At the end of the study, lettuce under LED lighting used significantly less hydroponic nutrient solution than those that under fluorescent lighting. Water productivity (biomass produced per unit of water used) was higher with LEDs. Electrical conductivity (EC) of the nutrient solution was lower in the LED treatment. However, there was no significant difference in the pH of the nutrient solution. Plant height, shoot dry weight, root dry weight, shoot:root ratio, total plant dry weight, partitioning of dry weight to the shoots, partitioning of dry weight to the roots, and SPAD readings did not significantly differ between light treatments. In conclusion, moving lettuce plants from initial LED lighting to later fluorescent lighting may enhance certain attributes of hydroponically grown compact lettuce.

Specified Source(s) of Funding: Hatch

(337) Growth Condition of Allium hookeri root By Heat Conservation Materials during Overwintering

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Allium hookeri is used for food and medical materials in Asia. It is a wild herb distributed in India and Myanmar but it is cultivated as a vegetable crop in Korea. It contains dietary sulfur compounds about six times higher than Garlic and protein, sugar, fiber, ascorbic acid, phytosterol and total phenol much higher than Onion. This study was conducted to identify appropriate heat conservation materials on A. hookeri during overwintering period. It was prepared approximately 5~6 cm length of root which contains four latent bud. In this study, Five mulching materials used during overwintering period were horticultural bed soil (30 mm thickness), straw (40 mm thickness), vinyl (0.1 mm, transparent), white nonwoven fabric (60 g/m²) and the control. During the investigation, the surface on minimum temperature by treatments was -15.8 °C ~ -2.4 °C, and maximum temperature by treatments was 9.8 °C ~ 28.7 °C. In the point of 15 cm under the ground, average humidity value on horticultural bed soil was 72.1%, on white nonwoven fabric was 53.3%, on vinyl was 59.6%, on straw 46.2%, and on the control was 55.7%. The latent bud in horticultural bed soil shoot out on 27 Feb., in white nonwoven fabric and vinyl shoot out on 28 Feb. and in straw and control shoot out on 2 Mar. On 9 Mar., horticultural bed soil treatment all shoot out, 95% can be seen on white nonwoven fabric, 76% can be seen on vinyl, 52% can be seen on straw and 46% can be seen on the control. The growth characteristics observed after overwintering period. The results suggested that horticultural bed soil (30 mm thickness) greatly increases the fresh weight. The most adequate type of Mulching materials on the plant growth of A. hookeri after overwintering was horticultural bed soil (262% higher than the control) and mulching materials were ranked in weight order. [white nonwoven fabric (45.1% higher than the control), vinyl (7.4 g/plant), and straw (2.3% higher than the control)]. Also, we measured root length, root thickness, dry weight, etc. With these results, this study suggested that adequate mulching materials on the growth of A. hookeri during overwintering was horticultural bed soil (30 mm thickness).

(338) Managing Greenhouse Bell Peppers for Optimal Yield

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Colored bell peppers (Capsicum annuum) are receiving increasing interest as a profitable greenhouse produced crop. To optimize greenhouse space and productivity, the plants are commonly trellised and pruned. A common production approach is to train...
two lateral shoots into a “V” system off the main stem. Pruning recommendations vary in respect to length and number of leaves to keep on the lateral branches developing on the two trellised stems. An experiment was therefore initiated to determine the effects of pruning method on yield in a two-stem trellising system. The six cultivars Fantasy (red), Fascinato (red), Organela (orange), Paramo (orange), Striker (yellow), and Tenato (yellow) were selected. The study was completed in a greenhouse covered with the acrylic material DEGLAS® and conducted from Feb. 17 through Sept. 28. Supplemental lighting from high-pressure sodium lamps was provided when outside ambient light dropped below 400 W·m⁻² between 6:00 AM to 10:00 PM. The plants were grown in a vertical high-wire drip irrigation system using dutch (bato) buckets (17.7 L volume) filled with a 50/50 mixture of perlite and a peatlite medium (Pro-Mix BX). The plants were divided into two treatment groups (n = 12) for the evaluation of pruning techniques. One set of plants was pruned so that each lateral side-stem was topped over one leaf while in the second group, three leaves were left. The fruits were harvested at maturity with at least 90 percent color formation. ‘Fantasy’, ‘Fascinato’, and ‘Paramo’ produced significantly higher yields in the three-leaf approach. There were no differences in yield for ‘Orangela’, ‘Striker’, or ‘Tenato’. During the production period from June through September, the highest yields were observed for the red peppers ‘Fantasy’ (4.7 ± 0.82 kg per plant) and ‘Fascinato’ (4.5 ± 0.69 kg per plant) in the three-leaf system. In contrast, the yield for the yellow peppers ‘Striker’ and ‘Tenato’ was 4.2 ± 0.67 and 4.0 ± 0.74 kg per plant independent of the pruning technique. ‘Orangela’ produced 3.7 ± 0.55 kg per plant in both systems while ‘Paramo’ (4.0 ± 0.68 kg) was more productive in the three-leaf approach. Size of individual peppers was similar for each cultivar independent of pruning technique. For those cultivars with higher yields, the increase was due to the development of additional, not larger, peppers. The average weight for a single pepper varied from 196 ± 39.1 grams for ‘Paramo’ to 245 ± 47.2 grams for ‘Striker’.

**Poster Session—Propagation 1**

(220) Commercial Orchid Production: Artificial/Synthetic Seed Approach

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Native and endemic species have always faced two common yet global conservation threats by overharvesting and habit fragmentation having historical resulted in the decreased fitness, extirpation, and extinction of various fauna and flora species through time on this planet. Of them, plants are compromised the most; they are non-motile which restricts their unique ranges, are naturally constrained by biotic and abiotic elements which can influence seed dispersals, and are artificially inhibited by human activities which has led to reductions in floral diversity across the globe. In this study, two critically threatened Floridian orchids (Oncidium ensatum and Bletia purpurea) were selected based on published Coefficients of Conservatism Values (CCV rating). Tissue culture carried out using seed-derived protocorm-like bodies (PLBs), through production of artificial/synthetic seeds (syn. Seed) by encapsulation of (PLBs) induced from wild seed. PLBs (2 to 4 mm in size) were chosen for the encapsulation process using 3, 4, 5% alginate, with three molar concentrations of CaCl₂ (25, 50, 75 and 100 µM), leaving a control treatment of PLBs without encapsulation. PLBs were exposed to different ranges of temperature (0 °C, 5 °C, 10 °C, 15 °C, and 20 °C) and storage duration treatments (15, 30, 45, 60, 75, and 90 d). The protocol was verified using tetrazolium chloride (TTC) assays to detect the PLBs’ viability ensuring that the embryos’ membrane would not be compromised, which can cause detrimental effects to plant growth and development. In conclusion, Florida is accented to be a sub-tropical hot-spot with its’ related rare, native and endemic species who are exposed to the factors listed above, with the addition of sea level rise, saltwater intrusion, and habitat pollution. The aim of this research was to introduce syn. seed production as potential propagation material for commercial floriculturist and as an alternative ex-situ technique that can be used by researcher and gene-banks to transport genetic material worldwide.

(221) The Effects of Light and Soil Moisture on Propagation of Linnaea borealis

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Linnaea borealis, or twinflower, is a clonal sub-shrub that is native to northern regions of the United States, Canada, Europe, and Siberia. It commonly grows in understory areas with partial shade, and soil moisture may be limited by competition for water with neighboring trees. Some growers report that this native plant is difficult to propagate, which is one reason that it is not abundantly available in the nursery industry. Twinflower populations are declining in some areas of the plant’s range. While twinflower prefers partial shade and grows in areas with limited moisture naturally, there has been no propagation work testing the impact of light or soil moisture conditions on root development of this plant. Therefore, our goal was to propagate twinflower under a variety of shade levels: 27.6, 14.4, or 5.8 mol·m⁻²·d⁻¹ and Θ (volume of water ÷ volume of soil): 0.30, 0.35, 0.40, and 0.45 L·L⁻¹. Soil moisture was controlled using...
Overhead mist facilitates the propagation of tender cuttings from a variety of taxa by preventing transpirational water loss. Despite its success, drawbacks to overhead mist include the application of large volumes of water, potentially unsanitary conditions, irregular misting coverage, and leaching of foliar nutrients. We explored the feasibility of three alternatives to overhead mist that might avoid these problems by applying moisture exclusively from below. These included 1) a sub-mist aeroponic system configured to provide intermittent mist only to the rooting zone, 2) a sub-irrigation system that provided water via capillary action through perlite from a reservoir maintained below the base of each cutting, and 3) a sub-fog aeroponic system (Nutramist) that was configured to provide constant fog only to the rooting zone. To initiate each system, we wetted perlite or filled reservoirs using either water or quarter-strength Hoagland solution. Each combination of system and fertilizer was replicated three times. A total of 240 herbaceous stem cuttings of coleus (Solenostemon scutellarioides ‘Wizard Mix’) were inserted into the systems for 21 days with 50% shading. Cuttings in the sub-mist system produced measures of rooting superior to those in the other systems. They produced more than three times as many roots as cuttings in the overhead mist system, with roots more than six times the length. Root dry weights averaged 28 mg among cuttings receiving overhead mist. The sub-fog and sub-irrigation systems produced results broadly comparable to the overhead mist. Fertilizer did not consistently improve rooting measures across the systems. Although we observed few root hairs on cuttings rooted using sub-mist, they transplanted well into a soilless substrate and quickly produced new root growth. The sub-mist system used less than one-fifth the water used by the sub-irrigation system, and less than one-fiftieth the water used by the sub-fog system. In comparison, a single overhead mist nozzle operating for 10 seconds released approximately one-third of the total water lost through transpiration from each sub-mist system over the entire experiment. Our results show that sub-mist systems merit further evaluation for propagation of plants by leafy stem cuttings. Potential advantages of propagation by sub-mist include lower water usage, less sanitation, lower potential for nutrient leaching, fast rooting, and rapid and non-invasive evaluation of rooting. The reason for improved rooting in the sub-mist system is unclear, and warrants further investigation.

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(222) Sub-mist Is an Effective Alternative to Overhead Mist for the Propagation of Coleus By Stem Cuttings
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The sub-mist system used less than one-fifth the water used by the sub-irrigation system, and less than one-fiftieth the water used by the sub-fog system. In comparison, a single overhead mist nozzle operating for 10 seconds released approximately one-third of the total water lost through transpiration from each sub-mist system over the entire experiment. Our results show that sub-mist systems merit further evaluation for propagation of plants by leafy stem cuttings. Potential advantages of propagation by sub-mist include low water usage, high sanitation, low potential for nutrient leaching, fast rooting, and rapid and non-invasive evaluation of rooting. The reason for improved rooting in the sub-mist system is unclear, and warrants further investigation.

Specified Source(s) of Funding: Maine Agriculture Center

(223) The Effect of Cutting Position Relative to Cotyledon on Survival Rate, Axillary Sprouts, Adventitious Root Formation, and Regrowth of Grafted Pepper Seedlings
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Producing grafted vegetable plants is complicated or made untenable by adventitious roots erupting from the scion axillary sprouts developing on the rootstock. Removing both unwanted organs is labor intensive but necessary in fruit production because their presence has several undesirable effects. Still, chemical-mediated removal of axillary sprouts is challenging because offsite movement of the chemical (e.g., to roots via stem flow) may damage the root system. The goal of this experiment was to document the effects of rootstock and scion seedling cutting position—above or below the cotyledon—on plant survival and regrowth, and axillary sprout and adventitious root formation. Seedlings of ‘Early Sunsation’ were used as the scion and rootstock when grafted to four other varieties (‘Jalapeño M’, ‘Cayenne Large Thick’, ‘Hungarian Hot Wax’ and ‘Thai Hot’) using the splice-tube method. Seedlings were cut either immediately above or below the cotyledons and plants representing three combinations of cut position were prepared: 1) scion epicotyl/rootstock hypocotyl; 2) scion epicotyl/rootstock hypocotyl, and 3) scion hypocotyl/rootstock hypocotyl. Twenty newly-grafted plants representing each of the eight variety and three cut-position combinations (24 treatments; 480 plants total) were arranged in a completely randomized design within a standard healing chamber in a climate-controlled greenhouse room at the OSU-OARDC in Wooster, OH. Plant survival rate and regrowth rates were recorded 15 days after grafting using destructive and non-destructive measures; adventitious root and axillary sprout development were also scored. The experiment was repeated twice June–September 2015. Survival and plant data were unaffected by variety combination and interactions involving variety combination and cut position were not significant. Percent survival (79%) was significantly lower among plants...
prepared with the scion hypo-/rootstock hypocotyl combination but it did not differ between the two other combinations, averaging 93%. Axillary sprouts developed in nearly 76% of plants with the scion epi-/rootstock epicotyl combination but not in any other combination. Similarly, adventitious roots developed in plants with the scion hypo-rootstock hypocotyl combination but not in any other combination. Plant fresh and dry weights were greater when both the scion and rootstock were cut at the epicotyl and similar in the other cut position combinations. Grafted plant leaf area calculated by WinCam from digital images was unaffected by cut position treatment. Additional related research is underway and involves seedlings representing the scion hypocotyl/rootstock epicotyl cut position combination.

(224) Deep Simple Morphophysiological Dormancy in Seeds of Epimedium koreanum
Nakai native to Korea

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The Berberidaceae is a family reported to have morphological dormancy (MD) or morphophysiological dormancy (MPD) with underdeveloped embryos. There are few reports on seed dormancy and germination in Epimedium koreanum Nakai. This research was performed to determine the type of dormancy for seeds of E. koreanum and its dormancy-breaking requirements. Seeds were collected on 5 June 2015, from plants growing in the Korea National Arboretum. Phenology of embryo growth, germination, and seedling emergence in field condition was observed. The effects of temperature sequences and GA, treatment on dormancy break and germination were evaluated. Seeds had underdeveloped embryos that were below 10% of the length of fully matured seeds. In phenology study, the embryos grew very little from June to early September, while rapid growth of the embryos was observed from late September to late November. Embryo growth was completed from late November until early December. Seeds sown on the field soil started to germinate from February, and most seedlings were observed on late March. In laboratory experiments, embryos grew rapidly when the seeds were moved from 25 °C/15 °C to 15 °C/6 °C (day/night). However, the embryos in constant temperatures (25 °C) grew very little. Most of the seeds germinated in only warm followed by cold temperature sequence. Therefore, it seems that warm followed by cold temperature sequence is essential for dormancy break and germination in the seeds. GA3 treatment increased embryo growth in the seeds, but none of them germinated at 20 °C. Based on these results, seed dormancy of E. koreanum can be broken through warm followed by cold temperature sequence and classified as having deep simple morphophysiological dormancy (MPD).

(225) Perigynia Removal Improved Germination in Two Native Sedge Species

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Sedges (Carex spp.) are used in wetland restoration projects and rain gardens because of their tolerance of fluctuating water levels. For larger projects, achene propagation is the most economical. Physiological dormancy is frequently reported in sedges and can be overcome by cold, moist stratification or after-ripening. Even when physiological dormancy is relieved, germination may still take several weeks. Removing the perigynium (perigynia, plural), a bladder–like sac that adheres to the pericarp of the achene, has decreased germination time and increased percent germination of some sedges. A growth chamber experiment was conducted to evaluate perigynia removal of four sedges native to the north central United States. Yellow fox sedge (C. annectens Bicknell), porcupine sedge (C. hystericina Muhl. Ex Willd), plains oval sedge (C. brevior Mack) and palm sedge (Carex muskingumensis Schwein) achenes were collected, cleaned and after-ripened. Achenes with and without perigynia were placed into petri dishes with moistened filter paper and grown for four weeks under 12-hours of cool, white fluorescent light, with alternating 27 °C, 10-hour days/15 °C, 10-hour nights with a 2-hour transition period between temperatures. Experimental design was a completely random design with four replicates. A species by perigynia interaction occurred. Removing perigynia significantly increased the germination percentage of yellow fox sedge from 40% to 62% and porcupine sedge from 79% to 98%. Perigynia removal did not significantly increase percent germination of palm sedge or plains oval sedge. Time to 50% germination was reduced for yellow fox sedge and porcupine sedge but not palm sedge or plains oval sedge. Perigynia removal is an effective strategy to increase percent germination and reduce time needed to achieve 50% germination of yellow fox sedge and porcupine sedge.

(226) Collecting Time Affected Immature Seed Germination of Kalmia latifolia L. Hybrids

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An asterisk (*) following a name indicates the presenting author.
and vigorous growth. When most of seeds became capable to yield good germination, mountain laurel hybrid fruits for immature seed germination. Early to mid-September should be recommended to collect fruits of two mountain laurel hybrids were harvested weekly from 14 July to 22 Sept. 2015, and disinfected. Cleaned immature seeds were then extracted and cultured in Murashige and Skoog (MS) medium with 3% sucrose and pH at 5.0. As collecting time went later, germination percentages and number of true leaves produced by immature seeds increased significantly. The germination percentages of ‘Minuet’ x ‘Snowdrift’ and ‘Pinkcharm’ x ‘Freckles’ ranged from 20.0% to 80.0% and from 12.5% to 82.5%, respectively. The lowest germination percentage occurred in July collection. Seeds collected in September germinated in 2–3 weeks and could yield 80.0% of germination. Seeds produced significantly more true leaves in September collection (5 leaves) than that of late August collection (2) after 8 weeks. Majority of seeds collected in July and early August failed to produce true leaf after germination. Early to mid-September should be recommended to collect mountain laurel hybrid fruits for immature seed germination when most of seeds became capable to yield good germination and vigorous growth.

Poster Session—Teaching Methods

(045) Enhancing the Learning Experience of an Online Plant Science Lab Course Using Moodle’s Tools and External Applications

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Over the past eight years, “Introduction to Plant Science” evolved from being offered face-to-face, to being fully on-line, including the lab activities. Students, at home, conduct the lab activities using a commercial lab kit, which is integrated with other course activities. Three types of direct assessment using pre-/post test quizzes and a rubric for the lab reports. Also, indirect assessment was done using pre-/post surveys of student self-assessment of their learning gains (SALG). Though using these tools, the course content and delivery is modified. One of the key enhancements is by increasing interactivity of student activities. Additional software tools are now used to develop modules with interactive student activities. These include adding immersive interactive 360 degree VR imaging as well as using Softchalk, ZebraZapps, and Adobe Captivate.

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(046) Demonstrating the Role of Plant Epicuticular Waxes in Water Retention on Leaf Surfaces Using Brassica Leafy Vegetables

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As the outermost barrier on plant surfaces, the epicuticular waxes create a hydrophobic surface that plays crucial roles in many important plant interactions with the environment, such as providing plants with tolerance to drought and resistance to pathogens and insects. Epicuticular waxes also affect surface retention of agricultural sprays like herbicides, pesticides, and plant growth regulators, and play an important role in postharvest quality of fruits and vegetables. We report here the development of an inexpensive and engaging laboratory-based activity that can help students learn about the role of these important plant waxes. After spraying water on leaf surfaces, this exercise demonstrates that much more water is retained on the leaf after epicuticular waxes are removed mechanically, than on a leaf having normal waxes. To provide more in-depth understanding, this exercise demonstrates the impact of these waxes on the leaf surface contact angles and shape of the water droplets themselves. Leaf surfaces of collard greens (Brassica oleracea L. Acephala group) are sprayed with water and then a digital camera is used to record contact angles and droplet shape, which are then quantified using ImageJ software, both before and after mechanical wax removal. The results demonstrate that droplets are broader, spreading to cover more surface area, and their contact angles are significantly reduced after epicuticular wax removal. As a supplement to this classroom exercise, images of surface wax crystals produced using a scanning electron microscope, and wax chemical composition determined using a gas-chromatograph/mass-spectrometer, for surfaces both with and without wax removed is presented to enhance student learning about how these epicuticular waxes shed leaf surface water, and to provide a foundation for instruction about the importance of the plant’s outermost hydrophobic barrier in protecting plants from environmental stress, and its affect on the efficacy of common sprays applied to control plant pests, kill weeds, and regulate plant growth.

An asterisk (*) following a name indicates the presenting author.
Peer teaching is a method in which students learn from each other, especially those who have more experience and knowledge about a particular subject material. Students undertake a teaching role to share their knowledge with other students. The objective is to describe how peer teaching was incorporated into an undergraduate tropical crop production systems course to supplement lectures and enhance student learning. TPSS 300 Tropical Production Systems has been taught through lectures and guest lectures by faculty in our department and college. Student evaluations indicated that there were discontinuities in the course because of so many guest lecturers. The course was modified by replacing some lectures with peer teaching. Cooperative learning was introduced in which the class was divided into small discussion groups of mixed ability with each person responsible for teaching others through answering assigned questions, sharing experiences, and searching the Internet for additional information. This semester there were three TPSS majors, one Natural Resources and Environmental Management major, one Management major, and one Exploratory Program major. Graduate students in the TPSS Department and the college were invited to guest speak in the course. This involved surrogate teaching, in which older students (often graduate students or advanced undergraduate students), have some teaching responsibility in undergraduate courses. Topics could be on their research, an agricultural job they had, a tour of their research experiments, foreign agriculture experience, an agriculture or sustainability project, or their family farm or nursery business. Students enjoyed peer teaching. In class periods in which the instructor lectured, students were sometimes hesitant to answer questions in front of the entire class. In small groups, however, students felt more comfortable and open when interacting with peers. Students received more individualized learning as they learned from each other in smaller groups, and the instructors were able to participate in the small group discussions. Direct interaction, participation, and dialogue among students helped promote active learning. More supportive relationships, social competence, and increased communication skills developed through the semester. Surrogate teaching involves giving older students (often graduate students or advanced undergraduate students), some teaching responsibility in undergraduate courses. By instructing others, the graduate student guest lecturers (peer teachers) reinforced their own learning. Teaching others helped provide a higher level of content mastery and a sense of accomplishment for them. In conclusion, peer teaching provides a structure for sharing knowledge, promotes active learning, and enhances student learning and teaching.

(048) Can You Hear Me Now? Good! How Graduate Students Learn to Communicate Science to the Public

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Being able to effectively describe one’s research interests to a broad audience is an incredibly important skill that students in the sciences often lack. This is because many students rarely have the opportunity to receive formal training to become an advocate for their subject of interest. We were interested in determining whether formal training in science communication helped graduate students improve their confidence and proficiency in communicating their dissertation research to a general audience. In Fall 2015, we designed and taught a new graduate-level course called “Communicating Science,” in which students learned different techniques to convey their research to a general audience using a variety of different methods (including elevator speeches, press releases, and social media). This course culminated with a “Student Science Series” night, a free event open to the local community in which students delivered short presentations on their research and fielded questions from the audience. We conducted a survey with students from a wide range of life science disciplines, including those who had taken our science communication course. In the survey, we asked students to respond to a series of prompts that assessed their ability to communicate scientific concepts to a lay audience (use of jargon, clear delivery of messages, appropriate analogies, etc.). We analyzed responses to measure if our former students showed an increased aptitude for communicating science when compared to students who did not enroll in our class. While this survey showed that students exhibited a wide range in proficiency for communicating science, we confirmed that our former students strongly felt that their enrollment in our course was largely helpful in improving their ability to communicate with the public. We therefore conclude that providing formal training in science communication can be extremely useful for graduate students’ professional development.

Specified Source(s) of Funding: National Science Foundation Graduate Research Fellowship

(049) Aggie B.L.U.E. Print Laboratories: Building Lasting University Environments—A Multi-disciplinary Teaching Opportunity

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Planning strategies emphasizing stormwater management, such as Low Impact Development (LID), are increasingly utilized in sustainable design/development, minimizing the impact of impervious land cover. LID is an innovative approach treating stormwater at the source, using uniformly distributed facilities such as stormwater collection devices, filtering systems, and water reuse mechanisms. This project seeks to educate and train students in LID alternatives to traditional stormwater management through hands-on outdoor classroom activities involving development, installation, monitoring, management, and evaluation of stormwater management designs within interactive test plots. Two sites on the Texas A&M University campus are being developed, one in which the primary challenge is runoff from building roofs and the other entails management of a large parking lot and turfgrass area effluent. Tasks are being carried out by students across three colleges (agriculture, architecture and engineering), including the Landscape Architecture and Urban Planning, Horticultural Sciences, Civil Engineering, and Biological and Agricultural Engineering departments. Provisions for solutions to complex hydrologic issues are being explored, assessed, and showcased as outdoor labs and interactive public exhibitions. Landscape Architecture and Urban Planning Students are providing the designs, Horticultural Sciences students are providing plant materials suggestions, propagating and growing plants for the project, and Engineering students are planning monitoring and environmental quality measurements. The three-year project employs long-term involvement in hands-on learning activities by an estimated 300 or more students per year and will result in solutions to two long-term water management problems on the Texas A&M University campus. Project objectives, plans, and current accomplishments will be addressed.

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(050) Does Incorporating Service-learning Across a Greenhouse Production Curriculum Enhance the Learning Experience?

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Greenhouse production courses generally focus on how to produce specific types of plants. However, increasing student understanding of why we produce greenhouse crops may enhance their learning experiences. The objective of our research was to quantify student attitudes toward service learning components in greenhouse production courses at Iowa State University. In Hydroponic Food Crop Production, students donated the produce produced to a local food bank specializing in perishable food and volunteered at the food bank. Students in Fall Greenhouse Crop Production selected different community partners in need and provided them with flowering potted plants. For Spring Greenhouse Crop Production, students produced annual flowering bedding plants for a children’s garden. A questionnaire was distributed to students in each of the crop production courses at the end of the semester containing four statements with Likert scale responses: 1) I see the value in connecting the technical skills we learn in class with a service project for a community partner (1 = strongly disagree, 4 = strongly agree). 2) Completing the service project enhanced the technical skills I learned in class (1 = strongly disagree, 4 = strongly agree). 3) I (1 = decreased, 3 = increased) the amount of effort I put into growing plants knowing a community partner was receiving the crops I produced. 4) Was the service learning component of this class . . . (1 = too little, 3 = too much). Across all three courses, students tended to strongly agree (3.6–3.7) that they saw value connecting what they were learning in the classroom and laboratory with their projects and agreed (2.8–3.2) that technical skills were enhanced as a result of their project. For all three courses students believed that the service learning component caused them to slightly increase their effort in producing greenhouse crops, with responses ranging from 2.3 (Spring Greenhouse Crop Production) to 2.6 (Fall Greenhouse Crop Production). While students generally thought the service learning component was not too much, student producing spring annuals for a children’s garden believed that the component was “just right” (2.0), while the students producing hydroponic food crops for the perishable food bank thought that the project was slightly more than they felt was appropriate (2.2). Based on our results, we believe that including service learning components to greenhouse crop production courses can positively impact the student learning experience and place their discipline-specific skills in a broader context.

(051) The Capstone Course—Benefits to Senior-level Students in the Agriculture and Food Systems Interdisciplinary Program at Washington State University

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Like many Land-Grant institutions in the United States, over the past decade, Washington State University has consolidated several of its former department-based undergraduate programs and restructured them into multi-departmental interdisciplinary degree programs. One such degree program is called Agricultural and Food Systems (AFS, afs.wsu.edu). The AFS program comprises five different majors: Agricultural Technology and Production Management Systems, Agricultural Education, Organic Agriculture Systems, Agricultural and Food Business Economics, and Agriculture and Food Security. This successful degree program currently has nearly 200 students enrolled. At the end of their program, students take AFS 401 “Advanced Systems Analysis and Design in Agricultural and Food Systems,” a senior-level capstone course. This course is designed specifi-
cally to provide a culminating experience to help in preparing students to be “job-ready, day one”. Guest lectures from industry professionals challenge students on topics including developing your personal brand, project management, sales 101, private agricultural business ownership and succession planning, and the performance review process. Teams of students work on relevant agricultural case studies and conduct research about various agribusinesses and present this information to their peers. In addition, a panel of recent graduates spend an entire class period fielding questions and sharing wisdom and advice related to lessons they have learned in their career. A fundamental part of the capstone experience is a team-based, semester-long project where groups of five students each work on addressing an emerging issue or problem and providing recommendations to one of several industry partners (co-ops, private companies, etc.). Students meet regularly with industry partners (face-to-face, videoconference, phone) to define their project, collect research information and develop a project plan. They prepare meeting agendas, take minutes and report back to instructors to identify what worked, what did not work, and what changes they plan to make for the next meeting. Besides introducing students to their business and colleagues, industry partners provide in-house research background information, assist in distributing employee surveys and provide excellent professional mentoring for students. At the end of the semester, student teams provide both a comprehensive written report and an oral presentation about their project and industry recommendations both to their peers and to industry leaders. The benefits and challenges of the capstone experience will be highlighted including results from both an on-line student exit survey and two facilitator-led focus group sessions with current students. Highlights of student led industry projects will also be shared.

(052) Fiction Writing As a Device to Introduce Horticulture Concepts in Extension

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Numerous examples of fictional scientific characters have existed in film, on television, and in books. These characters are often portrayed stereotypically as socially awkward (e.g. The Big Bang Theory), adventurous and heroic (e.g. Indiana Jones, Alan Grant), or as an evil genius (e.g. Dr. Frankenstein, Dr. Evil, Dr. Strangelove). The purpose of Extension is to make research available and understandable to the broadest audience possible. Scientific concepts are sometimes difficult to grasp for a layperson, but by employing devices that are familiar and accessible those barriers can be overcome. To address this gap, an Extension “hero” was created to take readers through the process of identifying problems, understanding options, and implementing solutions through scientifically sound processes. Dr. Cary Illinois was created to engage readers by solving mysteries, a popular literary convention. He is an Extension specialist who specializes in pecans, thus his name was borne from the binomial for pecan (Carya illinoinensis). The intended concept was to use common literary tropes (i.e. heroic main character, mystery genre) that readers can engage with and feel comfortable learning from, but put a different spin on them (i.e. “normal” person, no deaths) to relate them to horticulture science and Extension. In this way, the use of fiction dissolves the academic barrier between writer and reader and creates a more comfortable space for learning. To accomplish this, some rules were established, including: the mystery must not be complex and only address a single issue, eliminate confusion by limiting the number of characters involved, and avoid jargon that can obscure comprehension. To date, Dr. Illinois has appeared twice in Pecan South magazine with more columns forthcoming.

(053) Developing an Urban Food System Study Tour to Enhance Students’ Experiential Learning

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In Fall 2011, the Department of Horticulture, Forestry and Recreation Recourses launched a new specialization in Urban Food Systems (UFS) within our MS in Horticulture program. The core classes for the program include: HORT 791 Urban Agriculture, HORT 794 Urban Food Systems, and HORT 792 Urban Food Production Practicum. In these classes we use local examples of urban food systems, including in Manhattan, Kansas City, and other near-by communities. However, it is important to expose our students to other urban areas outside the Kansas City metro region. Therefore we developed HORT 795 Urban Agriculture Study Tour. This course not only gives the students new knowledge, but also helps them to develop contacts for job placement, and helps to advertise this emerging graduate program that is only available at Kansas State University. The intended learning outcomes of our study tours are 1) students will discover the actual context of UFS in a carefully designed faculty-led excursion and 2) students will apply their current UFS knowledge acquired in class and in practicum to the tour’s specific locations. From these intended learning outcomes, students will be provided opportunities to perfect their critical thinking and communication skills. We believe that one of the best ways for students to see what they have learned in the classroom is to apply that knowledge in non-familiar settings, like those encountered in a study tour. We expect that the conversations that our students have throughout the trip will build confidence, which is one of the most important outcomes of graduate education. During Fall 2015 we led our first study tour to Chicago, one of the top five cities in the United States leading the way in urban agriculture.

An asterisk (*) following a name indicates the presenting author.
Seven students and two faculty members visited 19 different sites including: urban farms and local food-related businesses, community development and social service groups, and not-for-profit organizations. The students had the opportunity to gain awareness about the complexity of issues surrounding urban agriculture and food systems work in Chicago. Additionally, we are conducting a study to document the value addition of study tours. The study began Fall 2015 with pilot-testing of the pre- and post-surveys of students in the study-tour course. This presentation will discuss how this course was developed as well as the challenges and the success we faced during that process, using both the faculty and the students perspective.

(054) The Purdue Arboretum’s Native Nursery Supports and Extends Experiential Student Learning
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In early 2014, the Purdue Arboretum began to expand its mission of collecting and displaying woody landscape plants to the Midwestern region of the United States by developing a native plant nursery. By April 2014, ground was broken at Purdue’s Meig’s Research Farm, allowing the native nursery project to fully take shape. Today, the Purdue Arboretum is producing 35 different species of trees and shrubs native to Indiana and is one of the largest on-going projects for the young arboretum. The Arboretum aims to produce a variety of native plants that will eventually be introduced on Purdue’s campus, allowing students and faculty to observe, learn, and appreciate our Indiana natives in the landscape. Through research, teaching, and outreach, we can encourage people to appreciate and find beauty in more sustainable landscapes that express the particularities of a place, its ecosystems and climate. The Purdue Arboretum native nursery initiative also aims to support and extend experiential student learning through active student involvement in the selection, care, maintenance, and research of the trees and shrubs at the nursery. This initiative encourages collaboration between faculty, students, and staff in the spirit of creating a living laboratory that will enable the campus community to explore the application of sustainability concepts in the campus environment. As example, in Fall of 2016, the arboretum nursery will be supplying plants for a campus redevelopment project. Todd’s Creek, currently channeled along State Street, the primary road leading to and through downtown West Lafayette and Purdue University, will be relocated to a more natural location within Purdue’s Horticulture Park. Over one hundred native plants, grown and cared for by Purdue students, will be harvested from the arboretum’s native nursery and planted by students along the re-located creek. This native nursery initiative also seeks to establish partnerships with commercial growers, horticulturalists, land managers, landscape architects and restoration ecologists. By identifying existing sources of locally-propagated native species and providing new research, this initiative will create a roadmap linking growers and consumers. This network will make native plants more diverse and readily available in the trade. The program targets both ornamental native species to be used in landscaping and native species needed for habitat restoration and rehabilitation projects.

(055) Facilitating Exposure and Understanding of Extension Resources to Undergraduate Students
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Today’s undergraduate students are the Extension stakeholders of the future. Too often graduates enter the workforce with little awareness and understanding of the trifold mission of land-grant universities, or how it can and should impact their lives both professionally and personally. While undergraduate students are regularly exposed to teaching and research activities associated with the land-grant mission, they often lack significant outreach exposure. Thus, undergraduates may not fully understand the role, value, and benefits of Extension programs. In order to increase awareness of Kansas State University’s (KSU) Research and Extension programs, students in the Fall 2015 Landscape Plants Identification course, were provided an opportunity to visit the KSU Olathe Horticulture Research and Extension Center (OHREC). Students (n = 15) voluntarily participated and spent the day interacting with and learning from K-State Research and Extension faculty and staff, and an industry expert. Field trip activities focused on the Prairie Star Flowers plant trial program as well as other Extension Research activities at the OHREC, including fruit and vegetable research and an Extension Master Gardener display garden. Students conducted their “annual flower” laboratory exercise amid the flower trials and while touring the facility. After touring the OHREC, students completed a retrospective survey to assess the impact of their experience and understanding of Extension. Survey results indicate an increased familiarity with Extension resources. For example, when asked to provide the definition of a land-grant institution, 9% percent of the students (n = 11) answered the question correctly and an additional 45% partially answered the question correctly. Students were also asked to identify the three mission areas of a land-grant institution. Of the 10 students who provided a response to the question, 60% responded correctly and another 20% were partially correct. When prompted to rate how relevant Extension was to them prior to visiting the OHREC and then after the visit (0 = not relevant; 1 = slightly relevant; 2 = somewhat relevant; 3 = moderately relevant; and 4 = very relevant), 53% indicated that Extension was ‘somewhat relevant’ and 27% rated it “very relevant” (n = 15) prior to the visit. An increase was seen in student relevancy ratings after the visit with 53% finding Extension ‘moderately

An asterisk (*) following a name indicates the presenting author.
relevant’ and 40% reporting it to be “very relevant.” Based on this initial study, adding Extension activities to undergraduate curriculum can increase their awareness and understanding of Extension. As future alumni and stakeholders, it is advantageous that they have an appreciation for and understanding of available Extension resources.

(056) Surveying Incoming Undergraduate Horticulture Students about Their Horticulture Backgrounds and Career Concerns

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Horticulture program enrollments across the nation, including the Horticulture Department at Kansas State University, have been in decline. This is concerning as there is an ever increasing need for graduates for the increasing number of career opportunities in the horticulture field. The objective of our research was to better understand the horticulture backgrounds of incoming freshman and transfer students and identify their concerns related to horticulture as they begin their undergraduate program at Kansas State University. With this information, our aim is to evaluate and assess our program’s current recruitment activities and consideration for new recruitment activities, in order to better direct limited resources to increase student enrollment in our undergraduate program. A survey was administered in the HORT 190 Preparing For Your Horticulture Career Course in Fall 2014 (F14; n = 40) and 2015 (F15; n = 46) semesters. Descriptive data was collected. In addition, students were asked open-ended questions, along with a list of several statements about horticulture and our program, in which they rated their responses (strongly disagree = 1; disagree = 2; neither agree nor disagree = 3; agree = 4; and strongly agree = 5). Sixty-eight percent and 67%, F14 and F15 students, respectively, indicated their high school did not have a horticulture course or program. When asked whether “The general public perception of horticulture is positive,” 68% (F14) and 76% (F15) agreed or strongly agreed with the statement. When asked whether they “had a good idea of a salary as a horticulture graduate” for the horticulture field, 43% (F14) and 57% (F15) agreed or strongly agreed with the assertion. This was interesting; as several students in each semester indicated that the amount of pay or salary was a major concern in response to an open-ended question about major concerns in their decision to get a horticulture degree. Another question asked if “I need a college degree to succeed in horticulture.” In the F14 and F15 semesters, 40% and 28%, respectively, of the students neither agreed nor disagreed, while 18% and 33%, respectively, either disagreed or strongly disagreed with the need for a college degree to be successful in the field. Based on our initial findings, it is clear that many horticulture students at Kansas State University are choosing the major, without any previous experience through their high school curriculum. Moreover, they are majoring in horticulture without a strong understanding of job opportunities available, salaries, and whether or not the degree will be necessary.

Poster Session—Vegetable Breeding

(152) Building Better Peppers: Characterization of a Variegated Pepper Line and Its Utility in Breeding Novel Fruit Types

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The heirloom pepper ‘Fish’ is an open-pollinated variety producing fruits with medium level of pungency and flavor. The plants that are short statured with average height of 2 feet, have variegated leaves and striped fruits that turn red upon maturity. We used this variety to introduce the variegation trait to an advanced breeding line of Capsicum annuum to develop a line with tall plant architecture, high yield, variegated leaves, and striped fruits which turn yellow upon maturity. The improved line was grown in a greenhouse and fruits were harvested for evaluation. Here we will report the ultrastructural details of the variegated fruit, carotenoid composition and postharvest keeping quality compared to another open-pollinated variety Georgia Flame.

Specified Source(s) of Funding: Specialty Crops Block Grant Program, Florida Department of Agriculture and Consumer Services

(153) Comparison of Six Green Chile (Capsicum annuum L.) Cultivars on Harvest Efficiency with Etgar® Picker

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Green Chile (Capsicum annuum) is one of New Mexico’s leading horticultural commodities. The crop is harvested when fruit are fully sized, but in the physiologically immature green stage, for fresh and processed markets. Mechanization is necessary to sustain the industry. Successful mechanization depends on harvester design coupled with plant growth habit that optimizes harvest efficiency. In a trial conducted at New Mexico State University’s Agricultural Science Center in Los Lunas, New Mexico, six cultivars provided by Curry Chile and Seed Co., Pearce, AZ (AZ-1904, Machete, PHB-205, E9, Specified Source(s) of Funding: Specialty Crops Block Grant Program, Florida Department of Agriculture and Consumer Services
(154) Genetic Diversity and Differential Host Pathogenicity Among Colletotrichum Causing Pepper and Tomato Anthracnose

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Anthracnose fruit rot is one of the most serious diseases affecting the production of tomato (Solanum lycopersicum) and pepper (Capsicum annum) in the United States. The disease is typically incited by Colletotrichum coccodes, C. gloeosporioides or C. dematium. Anthracnose has been typed as a disease of ripe fruit. However, Colletotrichum isolates causing disease on immature pepper fruit are becoming increasingly prevalent in Ontario and Midwestern, Southeastern and Mid-Atlantic production areas. Diverse tomato and pepper fruit rotting fungal isolates from infected fruit grown in the Mid-Atlantic region and previously described Colletotrichum exemplar strains were cultured from the U.S. National Fungus Collections. Pathogenicity of respective isolates on mature and immature tomato and pepper fruit was determined. Genomic DNA was extracted and nucleotide sequences of the rDNA-ITS region were determined. Phylogenetic analysis using maximum likelihood identified 15 clades among the 160 isolates evaluated. Based upon ITS similarity, isolates were assigned to Colletotrichum aggregate groups. Both tomato and pepper isolates grouped within the C. acutatum, C. gloeosporioides, C. truncatum and C. dematioidematiiformis aggregates. Multi-locus phylogenetic analysis using nucleotide sequence markers for GADPH, H3, ACT, CHS, and ITS data were utilized to determine species identities and determine lineage of isolates from different production regions and hosts. Opportunities to characterize fungal infection strategies and fruit defense responses will be discussed.

(155) Genetics of the Partial Resistance Against Race 2 of Verticillium dahliae in Lettuce

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Lettuce (Lactuca sativa L.) production on Coastal California is threatened by Verticillium wilt, a soil borne fungal disease caused by Verticillium dahliae, which diminishes yield and quality. Two races of V. dahliae were identified on lettuce, race 1 and race 2. Complete resistance to race 1 is conferred by a single dominant gene, but only partial resistance (PR) to race 2 is known. The objective of this research was to determine the inheritance of PR in 99 F2 families derived from a cross between PI171674 and PI204707 with PR. Plants were inoculated with race 2 isolate VdLS17 in two greenhouse experiments with three replications. The parents and the susceptible cv. Salinas were replicated 11 times. Disease Severity (DS) was rated on a scale of 0 (no root discoloration) to 5 (complete root discoloration and wilting lower leaves). Disease Incidence (DI) was calculated as the proportion of symptomatic plants. The Percentage of Foliar Wilting (PFW) and Days to First Flower (DFF) were also evaluated for each plant. Families were genotyped using the Genotyping-By-Sequencing approach based on digestion with the restriction enzyme AvaiI and SNPs were identified using TASSEL 3.0 GBS-pipeline. A genetic map was constructed using JoinMap and QTL analysis was conducted using Composite Interval Mapping feature of QTLNetwork. Both parents (PI171674, DI = 18% and PI204707, DI = 52%) had significantly less disease than Salinas (DI = 71%). In the F2 families, DI ranged 4% - 70%. Significant differences among F2 families for DI, DS and DFF were detected, but no families with resistance significantly higher or lower than both parents were found. Three QTLs were identified for DI, DS and PFW on linkage groups (LG) 5, 6, and 8 explaining 4%, 12%, and 6% of the phenotypic variation (R2),
Genotyping-by-sequencing (GBS) is a low-cost approach for characterizing genomes that can be used to assign individuals to populations and identify the genetic basis of phenotypic traits. Although a GBS work-flow (i.e., UNEAK) can be used to genotype species that lack a reference genome, GBS was initially designed to be used with a set of assembled reference sequences. Taro (Colocasia esculenta) lacks a reference genome, yet we have available genomic data from reduced representation sequencing; GBS of Hawaiian taro cultivars; GBS of two parents and their 92 progeny; Restriction-Associated DNA sequencing (RAD-seq) of the two parents; and publicly available taro transcriptome sequences (RNA-seq). In this study, we investigate methods to improve GBS results by creating pseudo-reference genomes for GBS read mapping. These pseudo-references were constructed using 1) only GBS sequences, 2) GBS and RAD-seq data, or 3) RNA-seq data alone. We found at least a two-fold increase in the number of single nucleotide polymorphic sites (SNPs) using any of our approaches versus the UNEAK GBS pipeline. We could also find associations between the genotypes of Hawaiian taro and their Hawaiian nomenclature, which often describe morphological features. Our method of using a pseudo-reference genome we expect will improve all downstream analyses, including linkage map generation and trait associations. This approach may be valuable to specialty crop researchers who want to revisit existing GBS data for species lacking a reference genome, and potentially to identify a better distribution of SNP sites across the genome.

Specified Source(s) of Funding: USDA- AFRI
Cowpea [Vigna unguiculata (L.) Walp.] is an important legume, and the antioxidant content in cowpea seeds has been recognized as a health-promoting compound for humans. The objectives of this study were to analyze the population structure of cowpea collections using single nucleotide polymorphism (SNP) and to identify SNP markers associated with the seed antioxidant content in cowpea. A total of 1047 SNPs were used to analyze 369 cowpea accessions from the core collection, originally collected from 47 countries. The STRUCTURE, TASSEL, and MEGA software programs were used to analyze the population structure and genetic diversity. Single marker regression (SMR), general linear model (GLM), and mixed linear model (MLM) in Tassel were used for association analysis between the SNPs and the phenotypic data of the seed antioxidant context and seed coat color. Results indicated that: 1) there was wide genetic variation in seed antioxidant content and coat color in the cowpea population and there were three clusters in the 369 entries based on SNP data; and the germplasm collected from India, South Africa, and the United States showed broader genetic backgrounds; 2) although different SNP markers were found to be associated with seed antioxidant content and seed coat colors with different models, the two SNP markers, Scaffold7139_14363 and scaffold29110_4657 were strongly associated with antioxidant content, and three SNP markers, C35063613_1497, scaffold81493_886, and scaffold84620_6785, were strongly associated with seed coat color across three models; and 3) Significant correlations were detected between the seed antioxidant content and black seed color (correlation coefficient = 0.45), between seed antioxidant content and red seed coat color (r = 0.50); and (4) Two SNP markers, Scaffold42008_191 and C3508238_2258, were associated with both seed antioxidant content and seed coat color, simultaneously. The SNP markers identified in this study could potentially be used in marker-assisted breeding to accelerate genetic improvement of cowpea for higher seed antioxidant content.

(159) Evaluation of Total Seed Protein Content in Eleven Arkansas Cowpea Genotypes

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Cowpea is cultivated on more than 11 million hectares with a worldwide production 5.4 millions of dried seeds. Cowpea is an affordable source of protein. Its protein is used as an alternative to soybean for people who are allergic to soybean protein. The aim of this research was to assess the variability of the total seed protein content in cowpea. Eleven Arkansas lines were used in this study. Field experiment design was randomized complete-block design (RCBD) with 3 replicates and conducted in three different locations within Arkansas State (Fayetteville, Alma, and Hope) in 2015. We performed a standard chemical protocol involving an analysis of the total nitrogen by combustion using an Elementar Rapid N III instrument to estimate the protein content. The average protein content was 25.4%, ranged from 23.7 to 27.4% with a standard deviation of 1.9%. The mean protein content of each line is ordered from high to low as: 09-204 (26.9%), 01-1781 (25.9%), 09-393 (25.9%), 09-208 (25.5%), 07-303 (25.2%), AR Blackeye #1 (24.9), 09-714 (24.9%), Ebony (24.9%), 09-655 (24.0%), and 09-741 (23.7%). T-test analysis indicated Early Scarlet and 09-204 were significantly higher than others, indicating the two lines had higher seed protein content. In addition, significantly environmental factor - location and G x E factor were also observed to affect the seed protein content (P < 0.0001). This study would be valuable by providing information on cowpea protein content for breeders to select and utilize those lines with high seed protein content in breeding program to release new high protein cowpea cultivars.

(160) An Edible Lily ‘Lanzhou Lily’ (Lilium davidii var. unicolor) Tissue Culture, Regeneration, and Micropropagation

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While many ornamental plants are known for their edible properties, only a few lily varieties are edible. Edible lilies play a major role in the lily industry in some Asian countries, attracting attention from consumers, scientists, and farmers around the world. Among the different edible lily species/varieties used for food, Lanzhou lily (L. davidii var. unicolor) is proved to be the best. There is no known Lanzhou lily cultivation in North America, therefore, no efficient propagation system is available. We established an efficient in vitro regeneration and micro-propagation system of Lanzhou lily. Among the different media and growth regulator combination tested, successful regeneration of adventitious shoots from bulb scale was achieved on MS medium supplemented with thidiazuron (TDZ) 2 mg/L, a mean number of 4 shoots can be induced from 0.5 cm² bulb scale cuttings, and the highest rate of regeneration is 98%. Shoots regenerated directly from the bulb scale without callus stage. Roots were induced from all the regenerated shoots on half-strength MS medium supplemented with 0.8 mg/L charcoal in 20 days, the acclimatization rate for in vitro plantlets is 100% in greenhouse. This protocol will be useful for introducing novel vegetables to new potential growing areas and may be used in Lanzhou lily mutation breeding.
(339) Fall Incorporation of Cover Crops Reduces Snap Bean Stand

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We tested whether it was better to incorporate cold-tender cover crops in the fall or spring in organic vegetable production. Fall tillage is often preferred because the soil is less likely to be wet, the soil warms and dries quickly in the spring, and freshly incorporated residue does not attract seed corn maggots. Delaying tillage until spring reduces erosion and allows more decomposition in place; it can also suppress winter annual weeds. We tested a crop of green beans following a cover crop of buckwheat, mustard, oats or sudangrass with plantings in Illinois, Michigan and New York in each of two years. With all four cover crops, the bean stand was lower if the ground was tilled in the fall. Fall tillage reduced the stand by >10% in three of five environments tested. Yield was reduced significantly in one of four environments where it was evaluated. Fall incorporation of cover crops represents a high risk relative to spring incorporation for organic bean management.

(340) Optimizing Compost and Fertilizer Rates in Organic Reduced-till Agriculture

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Interest in reduced tillage systems has been increasing and precipitated by a need to practice agriculture in a sustainable way in order to limit environmental degradation. The focus on preserving soil integrity has become commonplace in all scales of agriculture. Recently, trends in agricultural production have given rise to numerous small farms centered on local and sustainable farming. In turn, this has led to a growing desire to implement conservation tillage into these systems. In 2015 the first year of this multi-year experiment took place at the University of Maine’s Agriculture and Forestry Experiment Station: Highmoor Farm located in Monmouth Maine. The experimental treatments involved combinations of, pre-plant nitrogen (N) (bloodmeal), compost N, and side dressed N (bloodmeal). These were applied with rates of 40, 80, 120, and 160 pounds of N per acre. Compost was applied at three rates: 13, 26, and 40 cubic yards per acre either by banding over the planting row or broadcasting across the bed. Applications were incorporated using a yeoman plow. ‘Honey Bear’ a small bush type acorn squash (Cucurbita pepo) was grown. There was a linear relationship between increasing N per acre and fruit number, fruit weight, and stem biomass. However, yields from plots receiving N from only compost did not have significant differences between the 13, 26, and 40 cubic yards per acre treatments. The nitrogen source and application timing influenced yield; yield of plots receiving 40 pounds of N supplied by compost was significantly different from 40 pounds of N supplied by pre-plant fert. Likewise, yield from plots with a total of 80 pounds of N from compost was significantly greater than from plots with a total of 80 pounds of N with only pre-plant and side dressed N. A similar trend appears to take place in other treatments with a total N of 120 and 160 pounds per acre. There appears to be no difference in whether the compost was banded or broadcasted in the experimental plots.

Specified Source(s) of Funding: This experiment is being funded by the Organic Agriculture Research and Extension Initiative (O.R.E.I) and is being replicated by Cornell University at Freeville, and Riverhead, Long Island, NY

(341) Yield and Nutrient Influences of Organic Fertilizer Blends in a Plasticulture Tomato System

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We conducted a replicated trial of two fertilizer products derived from chicken (Gallus gallus) production to test their efficacy on the growth and yield of large-fruited tomatoes (Lycopersicon lycopericum Karst). We blended together a litter-based 3–0.87–2.49 (N–P–K) fertilizer and a feather-based 7–0.87–1.66 N–P–K fertilizer to create a complete pre-plant fertilizer [5.1:1:2.8 (N:P:K)]. We used this to grow slicing tomatoes in raised beds with drip irrigation and plastic mulch. Despite being bulkier than salt-based fertilizers, application of the products was easy prior to final bed shaping. We applied the blended materials at four effective total N rates: 75, 150, 225 and 300 lb/acre, with four replications. None of the treatments resulted in significant differences (P < 0.05) in yield or quality. However, all of the yield and quality categories measured had p-values below 0.17, and four of the eight categories of yield and fruit count had p-values less than 0.10, indicating the need to repeat the

An asterisk (*) following a name indicates the presenting author.
study. Increasing application rate increased leaf magnesium concentration. Application rate did not significantly alter leaf concentration of nitrogen, phosphorus, potassium, or calcium. Increasing the application rate resulted in increased leaf tissue manganese and boron concentrations. The product blends also had a highly significant influence on manganese concentration in the leaf tissue, more so than for any other nutrient tested. Chicken litter-based fertilizers often increase tissue copper concentrations and there was an indication that the blends we tested also increased copper levels in the leaves, although the effect was not consistent as rates increased.

Specified Source(s) of Funding: USDA Hatch Project MIS-149140

(342) Permanent Bed System for Small-scale Organic Reduced-till Agriculture

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For a diversified farm, permanent beds are a useful strategy for laying out the farm that aids in production planning where field traffic is restricted to the between-bed area, year after year. With compaction concentrated outside the planting area, growers can reevaluate the intensity, depth, area, and frequency of tillage necessary. We established a four year reduced tillage, permanent bed experiment in in the Fall 2014 at two locations: the Cornell Homer C. Thompson Research Farm, Freeville, NY, and the Highmoor Farm University of Maine Agricultural Experiment Station, Monmouth, ME. We applied 4 tillage intensities (from low-no till to high-conventional rototilling) to newly established permanent beds. The tillage main plots were arranged in strip-plot design and further sub-divided into three sub-plot mulching treatments: fall seeded oat/pea cover crop (no mulch), straw mulch, compost mulch. Tillage-mulch plots consist of three 4 ft. wide beds, each 25 ft. long, and with four replications. Here we report on three tillage systems (1 = no tillage, 2 = tarped no tillage, 3 = standard rototilling) in the no-till tarp system, we report on three tillage systems (1 = no tillage, 2 = tarped no tillage, 3 = standard rototilling) to newly established permanent beds. The tillage main plots were arranged in strip-plot design and further sub-divided into three sub-plot mulching treatments: fall seeded oat/pea cover crop (no mulch), straw mulch, compost mulch. Tillage-mulch plots consist of three 4 ft. wide beds, each 25 ft. long, and with four replications. Here we report on three tillage systems (1 = no tillage, 2 = tarped no tillage, 3 = standard rototilling) to newly established permanent beds. The tillage main plots were arranged in strip-plot design and further sub-divided into three sub-plot mulching treatments: fall seeded oat/pea cover crop (no mulch), straw mulch, compost mulch. Tillage-mulch plots consist of three 4 ft. wide beds, each 25 ft. long, and with four replications. Here we report on three tillage systems.

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

Specified Source(s) of Funding: USDA Hatch Project MIS-149140

(343) Fruit Yield and Ascorbic Acid Content of Pepper Plants Grown in Soils Amended with Organic Fertilizers Under Field Conditions in Southwest Texas

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Hot chili pepper (Capsicum annuum) production is a vital economic endeavor in the southwest of Texas. Organic fertilizers have been proposed as environmentally friendly alternative amendments to infertile soils that resulted from the intensified agricultural practices in chili pepper production. Manure (60 or 80 t/ha) and three commercial products (Soil Secrets® Terra Pro, Protein Crumbles, and TTP Supreme compost) were tested in two fields to grow ‘Cayenne Mesilla’ and ‘Chichen-Itza Habanero’ chili pepper plants from May to September, 2015. In each field, a total of 180 chili pepper plants were planted in nine raised beds with 20 plants in two rows of each bed. Treatments were applied randomly to either half of the bed. Plants were watered daily through drip irrigation system, twice (8 am and 12 pm) during spring and three times (8 am, 12 pm and 3 pm) during summer with an average of 506 ± 110.8 mL per plant. Beds were covered with black weed barrier fabric. Plant height at both locations. Soil temperatures were greater in tarped plots compared to un-tarped plots prior to tarp removal. Additionally, soil temperatures were greatest in un-mulched plots followed by compost and straw mulched plots. Tarped plots had fewer weeds and required less time weeding than the other tillage treatments. Soil moisture was greatest in straw mulched plots followed by compost and un-mulched plots. No-mulch plots had greater yields compared to mulched plots at both locations. In New York, mulched plots out yielded compost mulched plots though the difference was not significant. In New York compost and no mulch had significantly higher yields than the straw treatment. Over four years, this work will provide growers with more agronomic, ecological and economic information to evaluate reduced tillage practices for permanent beds.

Specified Source(s) of Funding: OREI 2014-05381
and two perpendicular widths were recorded weekly whereas chlorophyll fluorescence and SPAD readings were measured bi-weekly. Mature fruit were harvested weekly, and number of fruit and fresh weight (FW) were recorded. Aboveground shoots were harvested at the end of the growing season, and shoot fresh weight (FW) and dry weight (DW) were recorded. Ascorbic acid concentration was determined in mature fruit only. Data were analyzed with a factorial ANOVA at an α = 0.05 using SPSS statistics software. Results showed that plant height was different among treatments. At harvest, the manure treatment at 60 t/ha had the highest average fruit FW of 523.74 g per plant, shoot FW of 447.09 g per plant and shoot DW of 104.34 g per plant, while the Supreme compost treatment had the lowest average values of 371.3, 338.2, and 80.9 g per plant for fruit FW, shoot FW, and shoot DW, respectively. Chili pepper treated with manure at 60 t/ha had the lowest concentration of ascorbic acid (6.03 mg/g DW), while that in the control treatment had the highest ascorbic acid content (7.54 mg/g DW).

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**344** Sudangrass and Sorghum Sudangrass Hybrids As Summer Cover Crops for Rotational Plantings and Soil Health Improvement

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Sorghum and sorghum-sudangrass hybrids (Sorghum bicolor × S. sudanense) can be used as summer annual cover crops in vegetable crop rotations since they may fit into a second crop or in between crop. They may increase soil organic matter when grown properly and incorporated. Sudangrass and sorghum-sudangrass hybrids are annual warm season grasses that are heat and drought tolerant; making excellent summer cover crop choices. Both can grow from 1.83 m to 2.44m tall and produce large amounts of dry matter. Management considerations, like providing nitrogen fertility and mowing to increase biomass production via regrowth, can increase organic matter contribution to soil. Both of these cover crops winter kill with the first hard frost. Sundangrass and sorghum-sudangrass hybrids offer several benefits as a cover crop. They can be used to store residual nitrogen, suppress weeds, improve soil quality, and may suppress some nematodes. Research and grower experiences with sudangrass and sorghum-sudangrass for summer cover cropping has proven effective in improving soil health and subsequent crop yields and quality. Research showed, when grown for a 62-day period, at a seeding rate of 56.7 kg/ha, on sandy loam soils in Southern New Jersey, sudangrass (Sorghum bicolor var. sudanense) cv. ‘Piper’, yielded 4022.23 kg/ha dry matter. Although shown to provide multiple benefits, even when grown for a short period during a production system, wide scale adoption of sudangrass and sorghum-sudangrass hybrids has not occurred. The reason is mainly due to farmer time management in summer. Increased promotion and education about this practice is needed. For more information see the Rutgers NJAES fact sheet 994 at http://njaes.rutgers.edu/pubs/publication.asp?id=FS994.

**345** Strip Tillage and Cover Crop Effects on Tomato and Pepper Crop Productivity

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Standard vegetable production systems include raised beds topped with drip irrigation and plastic mulch is extremely popular; however, it also requires intensive tillage, which degrades soil structure, contributes to runoff and erosion, and intensifies reliance on non-renewable resources. Reduced tillage systems, on the other hand, lack these negatives but also have been less productive than standard systems. The type, condition, and location of the cover crop or its residue strongly influence the performance of strip-till systems. Two paired studies were completed in 2015 at the OARDC in Wooster, OH, specifically to document the productivity of pepper and tomato plants grown in plots representing different tillage and cover crop combinations. Each study (tomato, pepper) was a split-plot design with four replications, having system (raised bed and plastic mulch vs. flat strip-till) as the main factor and cover crop type (living mulch vs. dead mulch) as the sub-factor. The experimental area was sown to winter wheat in Fall 2014. In Spring 2015, regular plastic beds were shaped in experimental replicates after by moldboard plowing, herbicide and fertilizer application. Then, ryegrass seed was broadcast over the top and into the furrow of half of all raised-bed plots as living mulch; wind moved ryegrass seed to bed edges. For strip-till plots, wheat was mowed to promote tillering at regrowth. Two weeks later, wheat was killed with herbicide in the strip-till-dead mulch plots; while wheat was mowed a second time in strip-till-living mulch plots. Then, a PTO-driven roto-tiller with only one pair of tines was used to create 25-cm wide by 15-cm deep strips in the living and dead wheat plots. Tomato ‘Mountain Fresh’ and pepper ‘Aristotle’ were transplanted into the standard or strip-till plots in single rows. Plant growth and fruit yield were monitored in all plots. The tillage-cover interaction was not significant in either experiment (tomato, pepper). Tomato fruit yield and fruit number were similar between standard and strip-till plots but total and marketable fruit number and yield were greater in plots with dead compared to living mulch. Pepper values were more affected by system as marketable fruit number and yield values in strip-till plots tended to be 25% of those in standard plots. Also, for both crops, the harvest at which yield was greatest occurred later in strip-till than standard plots. Follow-up research will investigate additional factors that may influence the productivity of reduced tillage as systems as they apply to specific vegetable crops.

An asterisk (*) following a name indicates the presenting author.
(346) Sweetpotato Yields Among Small Vegetable Farmers and Potential to Increase Production in Southeast Virginia

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Consumption of sweetpotato (*Ipomoea batatas*) has increased in the past decade in part due to its nutritional and health attributes, and to the availability and convenience of processed products. Virginia used to raise 15,000 to 19,000 acres of sweetpotato in the 1960s with a market value of $5 to $8 million for the state, but this market share was gradually lost in the 1970s. With the expansion in sweetpotato production in the southeast, farmers in the coastal plains of Virginia and in the DelMarVa Peninsula have expressed their interest in growing sweetpotato and getting back their market share. This study investigated sweetpotato production in Virginia and the performance of recently released cultivars. A survey was conducted in 2015 including farmers from Virginia’s Eastern Shore, Northern Neck area, Virginia Beach Co., and Dinwiddie Co. Most field surveyed ranged between 2 and 4 acres except one organic field with 30 acres. Four 1-row plots, 10 ft. long, were randomly selected and hand harvested to determine yield. Cultivars grown by farmers included ‘Covington’, ‘Bearegard’, ‘Bellevue’, ‘Burgundy’, ‘Diane’, ‘Evangelino’, ‘Bonita’, and ‘O’Henry’. In addition, the NSCG cultivar trial was conducted at the Eastern Shore AREC, Virginia Polytechnic Institute & State University. The local ‘Hayman’ cultivar was included to compare with ‘Bonita’ and ‘O’Henry’. Experimental design was a CRB with four replications and plots consisted of one 20 ft. long row planted at 12 x 36 inches. Marketable yield among all cultivars from surveyed commercial fields ranged from 340 bushel/acre to over 1100 bushel/acre. Irrigation appeared to be the main factor for the significant differences in yield. Marketable yield from the cultivar trial at the Eastern Shore AREC ranged between 532 and 956 bushel/acre. These yields are well within the yields obtained in the main sweetpotato production states and therefore it appears to be a good alternative crop for farmers in Virginia.

(347) Anaerobic Soil Disinfestation: Carbon Rate Effects on Soil pH, Temperature, Redox Potential, and Tomato Plant Growth

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Anaerobic soil disinfestation (ASD) is a non-chemical soil disinfestation technique increasingly proposed for the control of soil-borne pathogens, plant parasitic-nematodes, and weeds in different crops. The technique consists of amending the soil with a readily available carbon (C) source, tarping the soil with impermeable mulch, and irrigating the soil to saturation to create anaerobic conditions that promote the growth of facultative anaerobic microorganisms, which produce organic compounds that are toxic or suppressive to soil-borne pathogens, nematodes, and weeds. The level of anaerobiosis achieved and the efficacy of the technique seems to be influenced by several factors, among which are the C-source and its application rate. Being locally available, molasses (Agricultural Carbon Source, TerraFeed LLC) has been proposed as a C-source in Florida. However, limited information is available on its optimal application rate. Therefore, a greenhouse pot study was conducted to evaluate the effect of increasing molasses (C) rates on soil pH, temperature, redox potential (Eh), and tomato (*Solanum lycopersicum* L.) plant growth. Black 10-L plastic pots were filled with sandy soil amended with composted poultry manure (22 Mg·ha\(^{-1}\)), and molasses was applied at the rate of 0 (control), 13,900, 27,700, 41,600, and 55,500 L·ha\(^{-1}\). Pots were saturated with 5 cm of water and tarped with a 0.03-mm black/white TIF mulch. Treatments were arranged according to a randomized complete block design with four replications and five pots per experimental unit. After three-week treatment, tomato seedlings (cv. Ridge Runner) were transplanted in each pot to evaluate the plant growth response. At the end of the three-week treatment period, soil pH decreased with increasing molasses rate, ranging from 8.4 in the control to 5.1 with the highest molasses rate. Cumulative-Eh was not influenced by molasses rates (54,000 mV/h), except for the control that showed significantly lower cumulative-Eh (11,000 mV/h). During the three-week treatment period, soil temperature was on average 25.8 °C and it was not influenced by molasses rate. Plant phytotoxicity, and 10% and 35% of plant mortality was observed with the highest molasses rates, respectively. Leaf, stem and total plant dry biomass were significantly influenced by the molasses rate. Total plant dry biomass was similar at 0 and 13,900 L·ha\(^{-1}\) of molasses, and consistently declined with increasing molasses rate. It is concluded that molasses may be an effective C source to induce reducing conditions; however, application rates above 13,900 L·ha\(^{-1}\) may be phytotoxic for the crop.

(348) Cover Crops and Strip-tillage Influence on Soil Health and Food Safety in a Midwest Muskmelon Production System

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Cucurbit growers in the North Central region face several critical challenges including increases in extreme rainfall events, increased soil erosion, decreased soil quality, and increased risks of fruit contamination with soil-borne plant and human pathogens. For example, recent outbreaks associated with foodborne illness...
threatened livelihood of melon growers, with *Listeria monocytogenes* and *Salmonella* killing consumers throughout the United States. Muskmelons (*Cucumis melo* L.) are a potential food safety concern for several reasons: the fruit is in contact with the soil throughout the growing season, the heavily textured surface of the rind is a challenge to sanitize, and the flesh is favorable for bacterial growth due to its moderate pH and high nutrient content. Adoption of reduced tillage practices, coupled with cover crop residues may help buffer cucurbits from rainfall extremes, suppress weeds, improve soil quality and health, and also reduce growth and dispersal of both human and plant pathogens. This study, conducted at the Horticulture Research Station, Ames, IA, investigated muskmelon (cv Aphrodite) production using three different cover cropping systems, cereal rye (*Secale cereale* L. ‘Wheeler’), cereal rye-hairy vetch (*Vicia villosa* ‘Purple Bounty’) mixture, and no cover crop, either conventionally tilled or strip-tilled after the cover crop was roller-crimped. The field was inoculated with *Listeria innocua*, a non-pathogenic species, and its presence was determined in the soil, on cover crop residue and on the exterior of fruit during the growing season. Conventional tillage showed the highest yield for marketable fruits. Conventional tillage treatment also increased soil NO₃-N concentration and EC. Strip tillage treatment suppressed the biomass and density of broadleaf and grass weeds in the between row area. Treatments had no significant effect on estimation of leaf chlorophyll (SPAD) or vine length. Both rye and rye-vetch eliminated populations of *Listeria innocua* in the soil, while no cover crop showed only a slight decrease. *Listeria innocua* was detected on rye cover crop residue at harvest.

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(349) Biodegradable Plastic Mulch Provided Weed Control, Yield, and Quality of Pie Pumpkin Comparable to Polyethylene Mulch

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The use of polyethylene (PE) mulch in agriculture has greatly increased worldwide in the last two decades. Mulching reduces weed pressure, moderates the soil temperature, conserves soil moisture and results in higher crop yield. PE mulch in most cases is not recyclable and its disposal can be a source of pollution to the soil and environment. Hence, mulch that can biodegrade in the field after tillage incorporation with no negative impact on the soil ecosystem would be highly desirable. In 2015, an experimental field trial evaluated four potentially biodegradable plastics (Metabolix, Organix, Naturecycle and BioAgri), a cellulose mulch [WeedGuardPlus (100% biodegradable)], PE (non-biodegradable) and no-mulch treatments for effects on pumpkin (*Cucurbita pepo* L. cv. Cinnamon Girl) fruit yield and quality. Two U.S. trial locations were selected based on distinct climate differences: Mount Vernon, WA, and Knoxville, TN. At Mount Vernon, the dry weight of weeds in the no-mulch treatment increased from transplanting to harvest (475 g·m⁻²), but there were no weeds in any of the mulch treatments except Naturecycle (0.1 g·m⁻²) at 2 weeks prior to harvest. At Knoxville, the dry weight of weeds was higher for the no-mulch treatment and Naturecycle from transplanting to harvest (71 g·m⁻² and 25 g·m⁻²); however weeds were not of practical significance for Naturecycle. At Mount Vernon, pumpkin marketable yield with BioAgri (24.3 t·ha⁻¹) and Metabolix (22.4 t·ha⁻¹) were comparable with PE mulch (27.3 t·ha⁻¹) while yield was significantly lower for the no-mulch treatment (11.3 t·ha⁻¹) and WeedGuardPlus (16.1 t·ha⁻¹); yield with Naturecycle (20.1 t·ha⁻¹) and Organix (19.7 t·ha⁻¹) were intermediate (*P* = 0.0002). These differences in yield may have been due to the difference in the soil temperature: at 10 cm depth, the temperature tended to be 2 °C lower for the no-mulch treatment (20.3 °C) as compared to PE, BioAgri and Metabolix (21.8 °C to 23.3 °C). At Knoxville, pumpkin fruit yield did not differ due to treatment (12.3–18.1 t·ha⁻¹), and soil temperature was higher in general for all treatments (25.3 °C to 26.9 °C) as compared to Mount Vernon. Pumpkin fruit quality (total soluble solids, dry matter, length and width) at harvest did not differ due to mulch treatment at either location. These results indicate that weed control, yield and quality of pie pumpkin grown with biodegradable mulch are comparable to PE mulch.

**Poster Session—Commercial Horticulture**

(021) Cultivation to Go

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*Specified Source(s) of Funding:* Otoke Horticulture, LLC

This presentation describes a turnkey solution to the challenges of managing a commercial cultivation operation. Developed from within the nascent Cannabis industry, a cultivation management platform is described that encompasses both the horticultural and business aspects of production plant cultivation. The platform rests on a tripod of education, standard operating procedures and operations management. While the elements of this platform are well known and widely practiced, it is noticeable that the only place all that information really and readily comes together was

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An asterisk (*) following a name indicates the presenting author.
in the proprietarily minded brains of commercial head growers. Working from our experiences over the past six years of cannabis consulting, the management platform presents a canned horticulture education element that reinforces the science behind the work. It lays out the mission critical tasks in detail along with tools to manage plant growth. The platform also puts in place a performance feedback loop on both horticultural and business levels, allowing for the kind of information growers use to manage not just the plant, but the business as well. With the ability to quickly provide candidates with a solid working knowledge of plant science and plant production, investors entering the cannabis space can now buy turnkey cultivation processes to go along with the already pervasive turnkey facilities.

(022) Effects of Adjustment to Spectral Ratios of Supplemental LED Lighting on Miniature Rose Growth and Morphology

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The DLI during winter months in the northern California ranges from 10–20 mol/m²/day and is inadequate for optimal plant growth. High Intensity Discharge (HID) lamps are commonly used as supplemental lighting in greenhouses to offset the lack of natural light are gradually being phased out in favor of light-emitting diode (LED) lamps for their higher energy efficiency and longevity. In some cases, LED lights allow users to manipulate the quantity and quality of light emitted from the various diodes composing an array. This lets the user “tune the spectra,” to controlling several aspects of plant growth including those usually controlled through use of Plant Growth Regulators (PGRs). Here we report use of spectral tuning during growth of miniature rose varieties ‘Renata’ and ‘Karina’ at Rocket Farms’ production greenhouse during winter months when supplemental lighting is a necessity. The HPS lights were used to illuminate a control group with an average PPFD of 74.25 µmol·m⁻²·s⁻¹, while three treatments consisted of a Full Power (FP) treatment at a PPFD of 61.5 µmol·m⁻²·s⁻¹ and spectral ratio of 65% Red : 5% White : 30% Blue, a High Red (HR) treatment for which blue light was eliminated for the final two weeks of growth (PPFD to 46.5 µmol·m⁻²·s⁻¹), and a High Blue/No PGR (HB/NPGR) treatment for which no PGRs were used. For the final two weeks of growth for this treatment red light was gradually reduced by 50% to a final PPFD of 33.5. Normal greenhouse conditions were maintained, and measurements were taken for height, width, and bud count weekly for four weeks. Our objective with HR was to attain similar or higher bud count than HPS was achieved with both ‘Karina’ and ‘Renata’. With ‘Karina’, the HR treatment achieved the same bud count as the HPS control, at 16.3 buds, while the FP and HB/NPGR treatments had a lower bud count of 14.25 buds. However, ‘Renata’ displayed no significant differences in bud count for HPS, FP, or HR with an average bud count of 4.7. HB/NPGR yielded a lower count of 3.3. Our objective of maintaining a shorter plant without PGRs under the HB/NPGR was achieved for ‘Karina’, while ‘Renata’ yielded a taller plant. These results confirmed that defined spectral ratios from supplemental LED lighting can influence plant growth similar to the action of PGRs, but that the degree of effectiveness is species or cultivar specific.

(023) Assessment of Basil Varieties for Production in the UVI Commercial Aquaponic System

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Basil is a fast-growing crop on aquaponics systems. Previous research has indicated that basil is a high cash-value for aquaponics, and the evaluation of species adaptation in tropical conditions is mandatory to recommend new varieties for the UVI Commercial Aquaponic System. Two trials were conducted to assess different basil varieties for production in aquaponics. In the first trial (Summer 2015), we evaluated five basil varieties (‘Genovese’, ‘Spicy Globe’, ‘Lemon’, ‘Purple Ruffles’, and ‘Red Rubin’), on a CRD with four replications. In the second trial (Fall 2015), we evaluated seven varieties (‘Genovese’, ‘Spicy Globe’, ‘Lemon’, ‘Purple Ruffles’, ‘Red Rubin’, ‘Cinnamon’ and ‘Thai’), on a CRD with three replications. In both trials, 3-week old seedlings were transplanted in net pots at a density of 16 plants/m². The first trial was harvested every 28 days, and the second trial was harvested before blooming, ranging from every 21 to 28 days. Plants were harvested four times by “cut and come again”, in which stems were cut 15 cm above the root and allowed to regrow until the next harvest. Two plants were harvested to determine fresh and dry mass. In the first trial, ‘Spicy Globe’ (12.11 kg/m²) and ‘Genovese’ (11.36 kg/m²) presented the highest total yield and ‘Purple Ruffles’ the lowest (3.49 kg/m²) (P < 0.0001). Plant fresh weight followed the same trend, and dry weight was higher on ‘Genovese’ (220.5 g/plant) (P < 0.0001). Leaf anthocyanin was higher on the red varieties ‘Red Rubin’ (34.36 ACI) and ‘Purple Ruffles’ (28.35 ACI) (P < 0.0001). Chlorophyll content was higher on ‘Genovese’ (48.594 CCI) (P < 0.0001). In the second trial, ‘Genovese’ (6.52 kg/m²), ‘Cinnamon’ (5.94 kg/m²), and ‘Spicy Globe’ (5.78 kg/m²) showed the highest total yield and ‘Purple Ruffles’ the lowest (1.48 kg/m²) (P < 0.0001). Plant fresh weight followed the same tendency, and dry weight was higher on ‘Cinnamon’ (81 g/plant) (P < 0.0001). Leaf anthocyanin differed in all varieties over time, with larger values on ‘Purple Ruffles’ (80.5 ACI) and...
‘Red Rubin’ (36.5 ACI) \( (P < 0.0001) \). Chlorophyll content was a response of variety and plant development, with readings ranging from 12 (‘Lemon’) to 18 CCI (‘Cinnamon’) \( (P < 0.0001) \). On both trials, plant width and height increased over time as expected \( (P < 0.0001) \). Based on our results, we recommend ‘Spicy Globe’ and ‘Genovese’ during summer and fall, were ‘Cinnamon’ is also an alternative. The total yield reflected the measured plant morphology. Varieties with smaller plant size can be spaced closely to increase total yields.

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### (024) Improving Cantaloupe Fruit Sugar Content in the UVI Commercial Aquaponic System

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Controlled water stress imposed during the reproductive stage of fruit crops are well-known for increasing flowering and fruit quality. However, deficit irrigation is challenging to apply on recirculating aquaponics systems due to the use of deep water hydroponic troughs for vegetable production. Our study evaluated the effect of partial root and canopy cut performed before two different harvest schedules on cantaloupe fruit sugar content. The UVI Commercial Aquaponic System used consisted of three main components: fish rearing, solids removal and hydroponic vegetable production troughs. The hydroponic troughs were 30 x 1.2 x 0.3 m with a volume of 11.3 m³ and a surface area of 214 m². The water flow rate on the troughs was 125 L/min for a retention time of 3 h. Fish waste products were the source of nutrients for plant growth. Three-week old cantaloupe ‘Goddess’ seedlings grown on peat-based substrate were transplanted into 1.2 x 2.4 m (2.97 m²) styrofoam rafts on the aquaponics system on 2 Oct. 2015. (day after transplanting, DAT 1). We planted 2 plants/raft spaced every 1.2 x 1.2 m in a density of 1.485 plants/m² and used 12 rafts/trough. Our treatments were the combination of partial root and canopy cuts (0%, 25%, 50% and 75%) in two harvest schedules (10 days after cutting or at fruit maturation), resulting in 20 treatments, in a CRD with two replications. The root and canopy cutting was performed on DAT 37. The first and last harvest were performed on DATs 47 and 64. Sugar content increased only on the treatments with no root cut, 75% and 25% of canopy cut and fruits harvested at the maturation (9.1 and 8.4 °Brix), with a negative effect on the treatment with 75% of root cut, no canopy cut and fruits harvested at the maturation (3.7 °Brix) \( (P = 0.0060) \). The treatment with no root or canopy cut and fruits harvested at the maturation promoted the highest yield (30.227 kg/ha), indicating a negative effect of the partial cutting on fruit total yield \( (P = 0.0072) \). No treatment response was found on fruit length and width, fruit hardness, fruit pulp thickness, leaf chlorophyll and anthocyanin content, root and shoot dry weight and shoot fresh weight \( (P > 0.05) \). Even though our results indicated an increase in fruit sugar content, more research is necessary to develop an alternative cultural practice for increasing cantaloupe fruit sweetness in aquaponics without compromising total yield.

**Specified Source(s) of Funding:** Funding for this research was provided by USDA-NIFA-Hatch Funds

### (025) Sun Exposure Affects Growth and Harvest Yield of *Ocimum basilicum* ‘Cardinal’ L. Grown on an Inexpensive, Vertical Structure

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Cardinal Basil (*Ocimum basilicum* ‘Cardinal’) was grown on a novel, inexpensive, A-frame vertical structure built at Auburn University. The structures were built out of treated lumber with cattle fencing on each of the 2 panel faces. One cattle fencing panel holds 15, 15.2 cm x 15.2 cm, square pots with one Basil plant per pot. In this study, one A-frame structure with the two panels facing opposite directions vertically occupied 1.5 m² of horizontal ground area, which is the same square footage the traditional, horizontal greenhouse bench treatment. The objective of this research was to compare how sun exposure, based on structure orientation, affects the growth and fresh leaf harvest yields of Cardinal Basil grown on the A-frame vertical structure compared to the traditional greenhouse bench. There were 4 blocks and 5 treatments per block: a south, north, west, and east facing panels and a horizontal bench (control). There were 15 plants per treatment, per block for a total of 300 plants in the study. Each pot received drip irrigation. Basil plants were harvested to three remaining nodes per plant every 4 weeks, to mimic harvests by a restaurant chef or homeowner utilizing the structure. On each harvest leaf number, fresh and dry leaf weights, and fresh and dry stem weights were recorded. Data results showed one south facing panel (0.75 m² horizontally) on the A-frame structure produced similar amounts of leaf fresh weight compared to the traditional greenhouse bench (1.5 m²). However, when looking at the A-frame structure as a whole (2 panels per structure; north and south or east and west) plants on each structure produced approximately 1.5 times more leaf fresh weight than those on the greenhouse bench. When comparing two south facing panels, they produced about two times the leaf fresh weight compared to the greenhouse bench covering the same horizontal production area.

An asterisk (*) following a name indicates the presenting author.
(026) Effect of Fertilizer Rate and Vertical Growing Structure Orientation on ‘Sweet ‘n’ Neat’ Cherry Tomato Production
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Vertical production has potential for economically providing local, fresh food utilizing limited space. This study evaluated the potential of a novel, inexpensive A-frame vertical structure for potential use in small-scale containerized cherry tomato production. Plant growth and fruit yield of ‘Sweet ‘n’ Neat’ cherry tomato (Solanum lycopersicum L.) produced on A-frame structures using 3 fertilizer rates was evaluated vs. plants produced using a typical horizontal container production system on a bench. The experimental design was a randomized complete block design with 4 blocks, 7 treatments, and 18 plants per treatment per block for a total of 504 plants. Six of the treatments were north and south oriented panels of the A-frame vertical structure each receiving one of 3 rates of fertilizer, 2.8, 4.1, or 5.5 kg/m², of Harrell’s 12–12–12, 4-month controlled release fertilizer. The seventh treatment was the horizontal bench control receiving 5.5 kg/m² of the 12–12–12 controlled release fertilizer. The first experiment round started at 16 Oct. 2015. There were two harvest on 5 Jan. and 25 Jan. 2016. Data collected included foliage nutrient content, total harvested fruit weight, and fruit number at four fruit maturity stages (green, turn, pink, and red). For both total harvested fruit weight and fruit number there was a three-way interaction between vertical panel orientation, fertilizer rate, and fruit maturity, regardless of harvest date. For tomatoes on south facing panels, green fruit weight and number increased with increasing fertilizer rate, while red fruit weight and number decreased. There was also a three-way interaction between panel orientation, maturity and harvest date, regardless of fertilizer rate for total harvested fruit number and weight. Plants on the south facing panels produced more red fruit during the first harvest, while plants oriented north had more green fruit during the second harvest. The total number of fruit harvested during the first harvest was twice that of the second on the south facing panel. Only orientation and fertilizer rate affected foliar nutrient content. Plants facing north had a greater nitrogen content than those facing south. Foliar nitrogen content responded in a quadratic fashion with increasing fertilizer rate.

(027) Comparing Culture and Planting Times for New Cultivar Releases of Rutgers Scarlet Lettuce®
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Two new, red lettuce cultivars touting high levels of anti-oxidants were trialed in Central New Jersey. Growth assessments compared spring versus fall planting times, plasticulture vs. bare ground culture, and field grown versus greenhouse production. Pelleted seed and transplants of the Rutgers red leaf and red romaine cultivars termed Rutgers Scarlet Lettuce (RSL) were planted in replicated plots (plasticulture) or bare ground 12 inches apart in double rows on a 28 inch bed with trickle irrigation. Spring season germination of field sown seed on white plastic averaged 63.3% for RSL leaf lettuce and 65.0% for RSL romaine. On black plastic, RSL leaf cultivar averaged 42.5% germination and RSL romaine 35.0%. Fall germination on both black and white plastic trended lower at 30.0% and 25.0% for RSL leaf and 55.0% and 55.0% for RSL romaine, respectively. Seed germination for greenhouse transplants in 50 cell trays was 96% or better in both spring and fall plantings which was significantly better at P > 0.05 than all field plasticulture and bare-ground treatments. This result was largely due to differences in soil temperature of a constant 80 °F from radiant floor heat with indoor cultivation vs. a variable field soil range of 48.5 °F to 69.6 °F in the first 21 days after seeding. Wet head weight from spring bareground trials for Rutgers ‘Scarlet Leaf’ and ‘Romaine’ averaged 232.6 and 246.0 grams, respectively. Wet head weight for RSL leaf lettuce in plasticulture averaged 138 grams compared to a standard red leaf cultivar Red Sails average of 195 grams. RSL romaine in plasticulture had an average head weight of 110 grams while standard green romaine was 204.1 grams. Other comparative cultivars generally grew larger as a semi-red romaine cultivar and red leaf lettuces as ‘Ruby Red’ and ‘Tasty Red’. There was no significant difference in germination, growth or yield between plasticulture colors. Late season bolting and a range of bitterness were evaluated in both the Spring and Fall field plantings of RSL lettuces. Both seasons were characterized with periods of rapid air temperature changes from low 60s °F to high 90s °F in eight separate plantings in two hydroponic operations with controlled climate, the quality of RSL lettuces were superior to field production with little to no bolting or bitterness.

(028) A Meta-analysis of Tomato Rootstocks to Determine Rootstock Vigor and Genetic Yield Potential
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The practice of grafting tomatoes (Solanum lycopersicum) in the United States is growing in order to utilize rootstocks that
confer resistance to soilborne plant pathogens, tolerance to abiotic stressors, and potentially increased vigor. The utilization of grafted plants can be especially beneficial for growers utilizing high tunnels, as limited crop rotation and intensive management practices can facilitate the proliferation of soilborne diseases. Grafting plants with vigorous or disease-resistant rootstocks allows for growers (especially those with limited space, or who are growing in high tunnels) to increase their productivity dramatically without increasing their production space. However, it is currently not clear how to identify which rootstocks show increased vigor and under what conditions. Therefore, the objectives of this study were to: 1) develop a meta-analysis approach to determine the characteristics of vigorous rootstock; 2) identify rootstocks that consistently showed increased vigor both across diverse production systems and under specific growing conditions; and 3) determine the relationship between increased vigor and genetic yield potential using data from on farm research trials. We used a meta-analysis approach to compile research data from 34 replicated grafting trials that were conducted in multiple locations throughout Kansas from 2011–15. We normalized yield data based on the impact of the rootstock as compared to the nongrafted control within each replication (rootstock/nongraft). We then used the normalized data set to measure the relationships between rootstock varieties and determine which rootstocks conferred the greatest production advantage, and under which growing conditions. Certain rootstocks showed improved production in almost all growing conditions and/or trials. Other rootstocks appeared to confer a comparative advantage primarily in growing systems with specific environmental or biological stressors, such as a soilborne disease. By combining data from multiple years and growing environments, this work will enable growers to select rootstocks that are tailored for their specific production system.

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**Poster Session—Ornamental Plant Breeding 1**

**(136) Utilizing Somatic Embryogenesis to Segregate Tissue Color Chimeras in Prunus serrulata ‘Royal Burgundy’**

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‘Royal Burgundy’ flowering cherry (*Prunus serrulata*) arose as a somatic mutation (branch sport) from the popular cultivar ‘Kwanzan’. ‘Royal Burgundy’ has desirable reddish-purple foliage color, but appears to be a chimeral mutation with peri-

**(137) SSR Markers Reveal the Genetic Diversity of Asian Cercis Taxa at the U.S. National Arboretum**

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

Redbud (*Cercis* spp.) are popular ornamental small trees or shrubs valued commercially for their showy early spring bloom, heart-shaped glossy leaves, and adaptability to diverse environmental conditions. The genus *Cercis* (Fabaceae) contains 7–13 species or sub-species that occur in North America, Europe, and Asia. There are more than twenty cultivars of eastern redbud (*Cercis canadensis*) and at least three cultivars of Asian taxa (primarily *C. chinensis*) in the trade. As part of an ongoing *Cercis* breeding program, the U.S. National Arboretum has amassed a diverse collection of *Cercis* germplasm collected in North America and Asia, as well as representative redbud cultivars sold in the United States. Because of their increasing popularity in cultivation in the U.S., we were particularly interested in clarifying the identity and diversity of the Asian *Cercis* accessions in our collection. We used 16 SSR markers to analyze the genetic diversity of 55 accessions of Asian *Cercis* taxa from our collection, including *C. chinensis*, *C. gigantea*, *C. glabra*, *C. racemosa*, and *C. yunnanensis*. These
SSR markers yielded an average of 5.8 alleles per locus (range 2–10), and were used to construct a phenogram using UPGMA clustering. Accessions tended to group by taxa or provenance, but there were some notable exceptions caused either by misidentification or nomenclatural confusion in the species. This information will be used to improve collection management and decision-making in the breeding program to maximize genetic diversity of cultivated Cercis.

(138) Induction of Tetraploid Hibiscus moscheutos through Soaking of Seeds or Seedlings
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Hibiscus moscheutos (2n = 2x = 38) is a herbaceous plant native to the eastern United States with a number of cultivars. Though possessing favorable characteristics of compact stature and large flowers in the midst of summer, they produce unsightly fruits, which reduce late-season flowering. To improve ornamental characteristics and sterility, induction of tetraploid clones was attempted. Colchicine and oryzalin were used as mitotic inhibitors to induce tetraploid breeding lines that will be used to develop sterile triploids. Pre-scarified seeds and germinated seedlings of the cultivar ‘Luna Red’ were used. Seeds and seedlings were treated at three different concentrations of each doubling agent for three different periods of incubation. Following treatments, treated plants were thoroughly rinsed with water and were planted in a greenhouse. Survival data on seeds and seedlings were taken six weeks after treatment. Because less than 5% of the seeds survived treatments, the seed experiment was terminated. The ploidy level of seedlings was determined via flow cytometry. Overall, survival percentage in colchicine treatments was higher than in oryzalin treatments. The group of 0.025% colchicine for 12 hours was the most efficient at inducing tetraploids (survival 57.5%, tetraploid 30%). Exposure to low concentrations of colchicine solution for a longer time or to a medium of oryzalin for a short period were considered to be efficient in yielding a high number of tetraploids with a low rate of mortality. Diploid, mixaploid and triploid plants were also compared with respect to their ornamental characteristics: flower size, flower petal anthocyanin content, leaf stomata size and blooming period. While no difference was observed in flower size, stomatal size or blooming period, tetraploid plants were found to have higher content of anthocyanin in flower petals compared to diploid seedlings.

Specified Source(s) of Funding: Institute of Plant Breeding, Genetics and Genomics, University of Georgia.

(139) Sequencing and Analysis of Leaf Transcriptomes of Impatiens Cultivars Differing in Downy Mildew Resistance
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University of Florida, Wimauma, FL

Impatiens downy mildew (IDM), incited by Plasmopara obdu
cens, is a devastating disease to the bedding plant and landscape industries in the United States and many other countries in the world. A good understanding of the molecular basis for the IDM resistance in New Guinea impatiens (Impatiens hawkeri) and its interspecific hybrid cultivars (Impatiens xhybrid hort) is of significant value for genetic improvement of garden impatiens (Impatiens walleriana) for resistance to IDM. This study was conducted to reveal the differences in gene expression between leaves of I. walleriana cv. Super Elfin® XP Pink and I. xhyrid hort cv. SunPatiens® Compact Royal Magenta, which are susceptible and resistant to IDM, respectively. Total RNA was extracted from fully expanded leaves of the two cultivars and their leaf transcriptomes were sequenced on Illumina HiSeq2000. Transcriptome assembly resulted in 121,497 unigenes with an average length of 1,156 nucleotides and N50 of 1,778 nucleotides. A total of 78,919 unigenes were differentially expressed between the two cultivars. Kyoto Encyclopedia of Genes and Genomes (KEGG) and Clusters of Orthologous Groups (COG) database searches predicted that 248 and 758 of the differentially expressed unigenes were related to plant immunity or defense. A total of 22,484 simple sequence repeats (SSRs) were identified in these unigenes, and trinucleotide SSRs, especially the AAG/CTT type, were most common. Searching for single nucleotide polymorphisms (SNPs) resulted in the identification of 245,936 and 120,073 SNP sites in SunPatiens® Royal Magenta and Super Elfin® XP Pink, respectively. The A-G and C-T transition type SNPs were most common in both cultivars. The obtained transcriptome sequences, the list of differentially expressed genes, and the SSR and SNP sites will be used to identify the gene(s) that are responsible for the resistance to IDM in I. hawkeri and its interspecific hybrids.

Specified Source(s) of Funding: The USDA National Institute of Food and Agriculture Hatch project (accession number 1009385), the USDA NIFA Specialty Crop Research Initiative (SCRI), and the Florida Department of Agriculture and Consumer Services Specialty Crop Block Grant Program.

(140) Sequencing and Analysis of the Transcriptomes of Young Ovaries of Lantana
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Genomes (KEGG) and Clusters of Orthologous Groups (COG) database searches predicted that 248 and 758 of the differentially expressed unigenes were related to plant immunity or defense. A total of 22,484 simple sequence repeats (SSRs) were identified in these unigenes, and trinucleotide SSRs, especially the AAG/CTT type, were most common. Searching for single nucleotide polymorphisms (SNPs) resulted in the identification of 245,936 and 120,073 SNP sites in SunPatiens® Royal Magenta and Super Elfin® XP Pink, respectively. The A-G and C-T transition type SNPs were most common in both cultivars. The obtained tran
scriptome sequences, the list of differentially expressed genes, and the SSR and SNP sites will be used to identify the gene(s) that are responsible for the resistance to IDM in I. hawkeri and its interspecific hybrids.

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(140) Sequencing and Analysis of the Transcriptomes of Young Ovaries of Lantana
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In the midst of summer, they produce unsightly fruits, which reduce late-season flowering. To improve ornamental characteristics and sterility, induction of tetraploid clones was attempted. Colchicine and oryzalin were used as mitotic inhibitors to induce tetraploid breeding lines that will be used to develop sterile triploids. Pre-scarified seeds and germinated seedlings of the cultivar ‘Luna Red’ were used. Seeds and seedlings were treated at three different concentrations of each doubling agent for three different periods of incubation. Following treatments, treated plants were thoroughly rinsed with water and were planted in a greenhouse. Survival data on seeds and seedlings were taken six weeks after treatment. Because less than 5% of the seeds survived treatments, the seed experiment was terminated. The ploidy level of seedlings was determined via flow cytometry. Overall, survival percentage in colchicine treatments was higher than in oryzalin treatments. The group of 0.025% colchicine for 12 hours was the most efficient at inducing tetraploids (survival 57.5%, tetraploid 30%). Exposure to low concentrations of colchicine solution for a longer time or to a medium of oryzalin for a short period were considered to be efficient in yielding a high number of tetraploids with a low rate of mortality. Diploid, mixaploid and triploid plants were also compared with respect to their ornamental characteristics: flower size, flower petal anthocyanin content, leaf stomata size and blooming period. While no difference was observed in flower size, stomatal size or blooming period, tetraploid plants were found to have higher content of anthocyanin in flower petals compared to diploid seedlings.

Specified Source(s) of Funding: Institute of Plant Breeding, Genetics and Genomics, University of Georgia.
**Poster Presentations**

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*Lantana camara* is a popular landscape plant and an important crop to the nursery and landscape industry, yet it has exhibited considerable invasiveness in certain regions and countries in the world. Efforts are being made to sterilize *L. camara* through production and selection of sterile triploids. These efforts have been hampered by the ability of *L. camara* to produce unreduced female gametes (UFGs) and apomictic seeds. In this study we report the sequencing and analysis of the transcriptomes of young ovaries of *L. camara* cultivar ‘Landmark White’ and breeding line GDGHOP36, which have different levels of ability to produce UFGs and apomictic seeds. Approximately 57 million sequence reads were obtained for each cultivar from Illumina HiSeq 2000 sequencing. Read assembling in Trinity software resulted in 74,029 unigenes with an average length of 1,038 nucleotides and N50 of 1,635 nucleotides. Functional analysis of the transcriptomes enabled annotation of 50,167 unigenes. There were 18,595 unigenes that were differentially expressed (DEGs) between the cultivar and the breeding line, and 1,467 DEGs seem to be related to cell cycle control, cell division, and chromosome partitioning. There were 12,091 simple sequence repeats (SSRs) in the assembled unigenes, dinucleotides SSRs being most abundant one with 3588 times present among dinucleotide SSRs. Single nucleotide polymorphism (SNP) search resulted in the identification of 89,252 and 101,976 SNPs sites in ‘Landmark White’ and breeding line GDGHOP36, respectively. Transition (A-G and C-T) SNPs were more common, with 53,455 and 61,182 sites in each genotype, respectively. The obtained sequences, gene expression data, SSRs, and SNPs will be used to further our understanding of the formation of UFGs and apomictic seeds in lantana.

**Specified Source(s) of Funding:** The USDA National Institute of Food and Agriculture Hatch project (accession number 1009385), the USDA NIFA Specialty Crop Research Initiative (SCRI), and the Florida Department of Agriculture and Consumer Services Specialty Crop Block Grant Program

(141) **The Effects of Ethyl Methanesulphonate and Sodium Azide on Plant Growth in Azalea (Rhododendron)**

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Mutagens have become an important tool in generating new variability that can be used to improve yield and quality in many crops and ornamental plants. The main objective of the experiment is to determine the effectiveness and optimum doses of chemical mutagens to induce the changes of growth and physiology responses in azalea by evaluating buds survivability (visual damage rating score), the height of new growth, new leaf number, leaf area, and chlorophyll content at different rates of ethyl methanesulphonate (EMS) and sodium azide (SA). The buds (wrapped by the absorbent cotton) of *G.G. Gerbing*’azalea plants were treated with EMS at rate of 0 (water), 30 mM, 60 mM, 90 mM, 120 mM, and 150 mM for 1d, 2d, and 3d, and with SA at rate of 0 (water), 2 mM, 4 mM, 6 mM, 8 mM, and 10 mM for 1d, 2d, and 3d. The treatment solution was applied in a closed frame covered with plastic film and black shade cloth. After each treatment time, the cotton was removed and all buds were washed under running water for two minutes to remove traces of mutagens adhering to the buds surface. Plants were then placed outside in a completely randomized block design (CRBD) for evaluation. Ethyl Methanesulphonate had lower buds survival rate and new leaf number than those caused by SA. In EMS, plants treated with 90, 120, 150 mM had the highest visual damage rating score, ranging from 9.6 to 10.0, while plant treated with 0 mM EMS had the lowest visual damage rating score, followed by those treated with 30 mM (4.6) and 60 mM EMS (7.2). There was no significant difference of chlorophyll content among 0, 30, and 60 mM EMS treatment solution. In SA, plants treated with 10 mM had the highest visual damage rating score (5.8), followed by 8 mM (4.1) and 6 Mm (3.9), 4 mM (2.7), 2 mM (1.4), and 0 mM (0.2). There was no significant difference of chlorophyll content among all SA treatment solution. In both mutagens, plant treated for 3d had the lowest buds survival rate and chlorophyll content. In summary, plants can be tested with EMS at rates between 60 and 90 mM for 2d, and with SA at rates higher than 10 mM for 3d in future research.

(142) **Resistance to Downy Mildew Caused By Plasmopara obducens in Impatiens at Different Growth Stages**

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Impatiens downy mildew (DM) caused by *Plasmopara obducens* is a devastating disease of garden impatiens (*Impatiens walleriana*) and has led to severe economic losses to the floriculture industries in the United States and numerous other countries in the world. New Guinea impatiens (NGI) (*Impatiens hawkeri*), by contrast, is reported to be highly resistant to DM. In this study, the resistance to DM in sixteen cultivars of impatiens and sixteen cultivars of NGI was evaluated at the cotyledon, first and second true leaf stages. Results from in-vivo inoculation assays showed that all *I. walleriana* cultivars were highly susceptible to DM, regardless of their growth stages, and all NGI cultivars were...
resistant to DM beginning at the first true leaf stage. During the cotyledon stage, the great majority of NGI cultivars showed some sporulation after extended incubation of artificially inoculated cotyledons, and I. hawkeri cultivars Divine Orange Bronze Leaf and Divine Burgundy showed significantly higher DM incidences than other NGI cultivars tested ($P < 0.01$). Leaf disc inoculation assays showed that the sporangia density on cotyledons of ‘Divine Orange Bronze Leaf’ was still two fold lower than that on the cotyledons and true leaves of I. walleriana cultivars at 10 days post inoculation (dpi). Growth and development of Plasmopara obducens in the inoculated impatiens leaves were examined by trypan blue staining and microscopic observation. Plasmopara obducens grew and developed rapidly on and in the leaves of I. walleriana cultivars, but did not start its lifecycle on and in the leaves of DM-resistant cultivars, with no fungal vesicle, hypha or haustoriums observed. Our results have shown complete resistance or immunity in many NGI cultivars beginning at the first true leaf stage and the possibility of screening for DM-resistant breeding lines and cultivars at this early stage.

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**Poster Presentations**

**(245) Flavonoids Distributing Profiles of Jujube in New Mexico**

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Jujube (Ziziphus jujuba Mill.), which belongs to the Rhamnaceae family, is becoming increasingly popular especially in the semiarid southwestern United States and it is considered to be an ideal economic crop for arid and semiarid areas where common fruit trees do not grow well. Jujube fruit is a well-known nourishing food and traditional Chinese medicine and the leaves have been exploited as tea. Flavonoids, important naturally occurring compounds, have been shown to have a wide range of biological and pharmacological activities. In order to determine the distributing profiles of flavonoids contents of jujube in New Mexico, we studied the effects of development stage, organ, and cultivar on the flavonoids contents of nine selected jujube cultivars from the NMSU Sustainable Agriculture Sciences Center at Alcalde, NM, with a spectrophotometric method. The flavonoids contents showed great variations ranging from 1.39% to 0.01% (dry weight) respectively, depending on the cultivar, fruit development stages and organs. During fruit development, the highest fruit flavonoids contents (average 0.74%) were at the very green fruit stage and decreased to the lowest at the mature stage (average 0.09%) among the nine cultivars tested. However, the highest flavonoids contents in leaves increased slowly and reached the highest at mature stage (average 0.51%). Of the nine jujube cultivars tested, ‘Li’ had the highest flavonoids content compared to other cultivars in all different fruit development stages and its contents may vary with cultural practices. These results indicate that ‘Li’ is a good germplasm for flavonoids research. With higher flavonoids content, green fruit or early mature stage fruit and mature leaves are suitable for flavonoid extraction or flavonoid component analysis.

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

**(246) Fruit and Flowering Habit of Mature ‘Wonderful’ Pomegranate (Punica granatum L.)**

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‘Wonderful’ pomegranate’s flowering and fruiting habits are not well understood. Characterizing any relationship(s) between flowering habit and fruit size and quality could lead to effective cultural practices for producing high-value fruit. Five mature ‘Wonderful’ pomegranate trees were monitored every 5–14 days throughout the 2015 growing season. Newly emerged flowers were tagged and characterized with respect to sex (determined by ovary shape and style length at anthesis), clustering habit, age of wood on which floral buds were borne, and direction of wood growth. More than 1100 hermaphroditic flowers were identified and ovary/fruit diameter was recorded throughout the season. In addition to tagging 1800 staminate flowers at anthesis, approximately 14,000 abscised staminate flowers were collected and used to estimate total flower number and the ratio of hermaphroditic to staminate flowers. Trees were strip picked at harvest. Fruit weight, maximum hemispheric diameter and exocarp color were recorded. Arils (seeds with a fleshy seed coat) were removed and weighed; aril number was estimated from the weight of 100 arils, and aril titratable acidity and total soluble solids were measured. The age of wood on which flowers were borne was a significant predictor of gender. One-year-old wood produced the highest number of flowers (70% of total) with the smallest proportion of hermaphroditic flowers (5%) for any age of wood. Two-year-old wood produced fewer flowers (19% of total) with 10% hermaphroditic flowers. Wood that was greater than two years old produced 10% of total flowers and 20% were hermaphroditic. Overall, 93% of the flowers were staminate. Despite the low proportion of hermaphroditic flowers produced on one-year-old wood, 57% of marketable sized fruit were produced on one-year-old wood. There were two distinct bloom periods, the first lasting approximately 9 weeks. Bloom time was highly predictive of fruit quality. Late-blooming flowers produced low-quality fruit that were smaller in diameter with fewer arils and poor exocarp...
color. Such fruit accounted for approximately 13% of total fruit weight. Location within the canopy influenced fruit diameter significantly. Flowering rarely occurred in the typically "closed" interior of the canopy and fruit in the Northwest tree quadrant were significantly smaller than fruit in other quadrants. The results suggest that development of cultural methods that limit excessive production of staminate flowers, reduce late-season flowering and/or fruit production and/or increase light exposure to fruiting wood could increase the production of high-value fruit for ‘Wonderful’ pomegranate.

(247) The Relationship of Seed Viability to Buoyancy in the North American Pawpaw (Asimina triloba)

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The North American Pawpaw [Asimina triloba (L.) Dunal] is a temperate member of the mostly tropical Annonaceae family native to the eastern United States. Pawpaws are forest understory trees that often grow in wet, fertile bottomlands and are a common inhabitant of riparian zones. Due to the abundance of pawpaw trees in riparian zones and its wide dispersal throughout the United States, a question has grown for understanding the tree's natural ability to proliferate and the methods by which this occurs. Animals, humans, and river systems have been speculated to play roles in the dispersal of pawpaw seeds. It has been demonstrated that riparian vegetation can greatly extend its range through hydrochory or the dispersal of seeds by water, especially if the seeds are buoyant. Pawpaw seeds can be subjected to many different lengths of time in the water and the seeds have varying floating capacities. Seed buoyancy is also of interest to nurseries that wish to clean seed through float protocols and propagate trees for sale. The objective of this study was to determine the viability of pawpaw seeds that float or sink when placed in water for 24 hours. Pawpaw fruit of mixed backgrounds were collected from Kentucky State University’s Harold R. Benson Research and Demonstration Farm in September 2015 and their seeds removed. Seeds were divided into 100 seed batches and were either: subjected to a floating treatment and placed in a growth chamber, subjected to a floating treatment and stratified, or stratified and then subjected to a floating treatment. For the floating treatment, 100 seeds were placed in a tray with 6 cm of water and an air stone to provide water circulation. Sinking seed were removed at 0, 1, 3, 5, 12, and 24 hours and placed into labeled bags. After 5 hours, the majority of the seeds had sunk. Seeds were placed into a 20 °C incubator to evaluate germination rates of the different groups of seeds, which will be discussed.

(248) Consumer Preference for Pawpaw Cultivars and Kentucky State University Advanced Selections

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The pawpaw [Asimina triloba (L.) Dunal] is a tree fruit native to much of eastern North America. Pawpaw is being grown commercially on a small scale in the United States and worldwide, with increasing interest in recent years from consumers, restaurants, wineries, and other processors and retailers. Kentucky State University (KSU) has the only full-time pawpaw research program in the world. One of the goals of the program is to enhance and improve the pool of commercially available pawpaw cultivars by conducting germplasm evaluation and breeding, in order to develop superior advanced selections for future release. The objective of this taste trial was to compare consumer preference of currently available pawpaw cultivars to KSU advanced selections. A tasting panel was conducted at the KSU Third Thursday Thing sustainable agriculture workshop. Varieties evaluated included the cultivars Susquehanna, Sunflower, Potomac, Taytoo, Mitchell, and KSU-Atwood™; and KSU advanced selections Hi7-1 and Hi4-1. Participants tasted and evaluated the fruit on flavor, texture, and appearance on a scale of 1 to 5, with 1 being poor and 5 being excellent. KSU advanced selections and cultivars compared favorably to currently available cultivars. Flavor of KSU-Atwood, Hi4-1, and Hi7-1 rated significantly higher than the older cultivars Taytoo, Sunflower, and Mitchell. KSU selections and cultivars were also rated highly on texture compared to older cultivars. Appearance did not vary significantly among varieties. There appears to be a trend for recent improved releases to be preferred by consumers, with KSU advanced selections and recent cultivar releases ranking highest in this evaluation, followed by Neal Peterson releases from the early 2000s; and older cultivars selected in the 1960s–1970s being less preferred by consumers.

(249) Fruit Characteristics of Four Pawpaw (Asimina triloba) Advanced Selections from Kentucky State University

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The North American Pawpaw (Asimina triloba) is a tree fruit native to the Eastern United States that is being produced in commercial orchards across the United States and internationally, with a small but growing market. There are approximately

An asterisk (*) following a name indicates the presenting author.
50 pawpaw cultivars available, but many of these varieties tend to be low yielding and have fruit sizes of 120 grams or less. Pawpaw varieties with fruit weighing over 120 grams are considered to have a large enough fruit size for commercial sale and processing. New high yielding cultivars with excellent fruit quality would further assist in the development of the pawpaw industry. Kentucky State University serves as the National Clonal Germplasm Repository for Pawpaw. Two goals of the Repository research efforts are germplasm acquisition and evaluation. The repository contains over 2000 accessions from 16 different states; additionally, both open pollinated seedlings from superior genotypes and crosses of superior selections have been incorporated into the repository collection. Fruit from four KSU advanced selections (Hi 1-4, Hi 4-1, Hi 7-1, and Hi 7-5) were compared to fruit from the commercially available selection ‘Sunflower’ or the basis of fruit weight, percent seed, and soluble solids. All selections except Hi 7-5 had significantly larger fruit than ‘Sunflower’, with selection Hi 1-4 averaging 310 grams per fruit. Hi 4-1 had the lowest percent seed (4.39%) and ‘Sunflower’ had the highest (8.58%). Selection Hi 7-5 had the lowest Brix reading (19.67) while Hi 4-1 had the highest (25.64). All four advanced selections show potential to be promising new releases and are being budded onto seedling rootstock for further evaluation.

(250) Changes of Tree Growth and Fruit Characteristics on Different Temperature Conditions during Growth Stages in Grapevine (cv. Kyoho)

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Changes of the growth patterns and fruit quality of ‘Kyoho’ grapevine in response to four different temperature conditions using the temperature gradient chamber were investigated. The temperature conditions consisted of 20.4 °C (group I), 21.1 °C (group II), 22.0 °C (group III), and 23.4 °C (group ‡W) during the growth period (April–October). Shoot diameter was the highest in group III, and it was decreased in group ‡W, group II, and group I. Berry setting density was the highest as 4.1 berries/cm in group I, but was lowest as 2.2 berries/cm in group ‡W. In the results of investigating the fruit characteristics, cluster weight was the highest in group II as 527.5 g, it was decreased in group I as 495.3 g, group III as 449.8 g, and group ‡W as 431.2 g. Total free sugar content was remarkably decreased in high temperature condition, and Tartaric acid was similar value in entire treatments except group III. Regarding sun burn and berry cracking at harvest, sun burn rate was remarkably increased in group ‡W as 8.3%, and berry cracking rate through water immersion was the lowest in group I as 20.0%, but it was relatively increase in high temperature conditions such as group II, group III, and group ‡W.

(251) The Kentucky Eastern Filbert Blight Resistant Hazelnut Trial

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The European hazelnut (Corylus avellana) has potential as a niche crop for small farmers in Kentucky for both in-shell nut sales at farmers’ markets and shelled nuts in value-added products. Susceptibility to eastern filbert blight (EFB) has limited the past use of European hazelnut cultivars in this region. Recently released hazelnut varieties from Oregon State University have high resistance to EFB and could serve as potential new cultivars for the region. The objective of this study was to examine regional suitability of five EFB resistant hazelnut cultivars, Jefferson, Yamhill, Gamma, Eta, and Theta in Kentucky plantings. Jefferson and Yamhill are main crop cultivars, whereas the other selections are mainly considered pollinizers. The cultivars Jefferson, Eta, and Theta have late blooming characteristics and may avoid late season frost and freeze events in our region. These trees were selected in the Willamette Valley in Oregon and were not specifically selected for winter hardiness in the Kentucky region; therefore, the critical winter temperatures for tree damage are not known. Additionally, it is not known if these varieties will flower early in the spring and be damaged by frost events. Trees were planted in Spring 2011 at Kentucky State University (KSU) and the University of Kentucky (UK). Deer damage led to problems establishing the trees for the first two years. Better electrical fencing was established at KSU in 2013 and trees were also left in bush form with approximately five stems each. In 2015, trees flowered on March 23, 2015 at the KSU Research and Demonstration Farm and flowered on March 25, 2015 at the Robinson Center for Appalachian Resource Sustainability, near Jackson Kentucky. At KSU, eleven out of forty trees flowered; five ‘Yamhill’, three ‘Theta’, two ‘Jefferson’, and one ‘Gama’ tree. At Jackson, 15 of 19 trees flowered. Three of four for ‘Gamma’, ‘Theta, and ‘Eta’ and two of three for ‘Jefferson’. All the ‘Yamhill’ flowered. At KSU nuts were
produced for the first time, with Gamma trees having the most nuts per tree. Nuts were also produced for the first time at the Robinson Center, but all nuts were hollow.

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

Poster Session—Undergraduate Student 2

(009) Micronutrients and Essential Oils in Sweet Basil (Ocimum basilicum L.) Grown in an Aquaponics System

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Chicago State University (CSU) aquaponics system uses the water from the fish tanks to supply the nutrients for sweet basil (Ocimum basilicum L.) in a continuous re-cycling of water. The relative proportions of soluble micro nutrients available to sweet basil plants by fish excretion do not mirror the proportions of nutrients assimilated by normally growing plants. Deficiencies in these nutrients result in symptoms ranging from brown/yellow leaves, small plants, and poor root structure to overall poor crop yield. It has also been reported that these micronutrients play a key role in basil essential oil biosynthesis and quality and are strongly affected by deficiencies in one or more of these nutrients. The essential oil compositions were determined by microwave extraction followed by gas chromatography/ mass spectrometry (GC/MS). Inorganic micronutrients were determined by microwave digestion followed by inductively coupled plasma mass spectrometric analysis (ICP-MS). Potential correlations between essential oil profiles and micronutrient concentrations will be discussed. We will also compare essential oil profiles of CSU aquaponics sweet basil with sweet basil obtained from local grocery stores.

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(010) Sustainable Production of Living Organic Container-grown Kitchen Herbs

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There is a market for 4-inch container-grown living organic kitchen herbs. Organic container-grown kitchen herbs provide easy access to fresh windowsill herbs that can be cut when needed by homeowner. The objective of this research was to develop an organic production system utilizing a constant water subirrigation system for delivering water and fertilizer for container herb production. The initial experiment compared two seeding rates (10 or 15 seeds/container) and fertilizer source for sweet basil (Ocimum basilicum) and cilantro (Coriandrum sativum) production. Potting substrate was Black Gold, an OMRI certified product, containing worm castings. Fertilizer treatments included water only (where the nutrients were only supplied by the potting substrate), poultry feather meal (12% N) incorporated in the substrate at 7 g/L, liquid Daniel’s (3–1–1) and Peter’s fertilizer (20–10–20) in the irrigation water at 100 ppm. Plants were harvested after five weeks and evaluated for plant height, biomass, leaf cover and relative chlorophyll content. Seeding rate did not impact plant quality in cilantro, but basil plants seeded at 15 seeds per container produced greater biomass and overall leaf cover compared to the lower seeding rate. Plants irrigated with water alone produced inferior plants for all measured parameters, while the highest quality plants were observed in the inorganic Peter’s fertilizer treatment. Basil and cilantro plants treated with Daniel’s fertilizer showed statistically higher biomass compared to the water only treatment, but had lower fresh and dry weights compared to the feather meal and Peter’s fertilizer-treated plants. Basil and cilantro plants treated with feather meal or Peter’s fertilizer produced commercial quality plants. Basil plants treated with feather meal or Peter’s fertilizer were comparable for biomass and final leaf cover. However, feather meal-treated cilantro plants showed significantly less biomass compared to the Peter’s fertilized plants. Relative chlorophyll content (measured in SPAD units) indicated that only basil and cilantro plants fertilized with Peter’s liquid fertilizer and incorporated feather meal were being supplied with adequate nutrition. This initial study demonstrated that commercial quality organic basil and cilantro could be produced using a constant water capillary mat irrigation system. Additional studies will compare living herb production in traditional plastic versus alternative biocontainers.

(011) Growth and Development of Two Fall-planted Kale Cultivars

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Kale, (Brassica oleracea, var. acephala), is a popular vegetable, known for its high health benefits. The crop can be grown in the fall and winter months as it is hardy and tolerates cold temperatures, even frost or snow if fully matured. On the Delmarva Peninsula, temperatures can dip below freezing for
extended periods during this time and therefore our goal was to evaluate how two cultivars, Toscano and Premier grew and developed in two different nutrient treatments in the prevailing weather conditions of the region. Seeds of the two cultivars were planted in early October 2015 in field plots containing the fertilizer treatments, Nature Safe or poultry compost. The design was a randomized complete block with factorial arrangement of the applied nutrients and cultivars. Seed germination averaged between 57% and 69% at 21 days after planting (DAP). The extra dark green and savoyed Toscano leaves had higher SPHAD values than the lighter green Premier. At harvest at 61 DAP, Premier had highest plant and shoot biomass when grown in Nature Safe treatment. Continued monitoring of the plots beyond harvest, showed new plants in the both the harvested data rows and unharvested border rows of Premier in early spring, but none for Toscano. Temperatures from planting to the final observations in early spring ranged from –0.5 °C just before harvest to 20 °C immediately following harvest and –18 °C later in winter. The results from this trial indicate that the cultivar, Premier is better adapted to growing in the fall climatic conditions of the region than Toscano.

**(012) Panax Ginseng Extracts As a Novel Antibiotic**

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Typical antibiotics seek to kill all bacteria, but when they fail a resistant strain of bacteria is formed and more powerful, harmful forms of antibiotics need to be used. A novel method of treatment is attempting to block the communication that takes place through chemical signaling between bacteria in order to prevent a bacterial infection from establishing. This practice is called anti-quorum sensing. Panax ginseng is a well-established inhibitor of quorum sensing. However, previous studies were unable to decipher the active chemical compound in these extracts that was responsible for the anti-quorum sensing property. One of the compounds that were identified in ginseng extracts was L-arginine (~80 mM). Further analysis with this particular amino acid showed a significant inhibition of quorum sensing phenotypes as detected through LasA protease and LasBelastase assay using *Pseudomonas aeruginosa* as biomonitor strains. The objective of this study is to confirm our initial findings through estimation of the quorum sensing signaling molecules, which are Acyl Homoserine Lactone (AHL) levels. The quantification of the AHL will be done using mass-spectrometry with the compounds detected in solvents acetic acid and sodium hydroxide from *P. aeruginosa* PA01 strains. AHL standards will also be added as controls. The ability to identify *P. ginseng*’s anti-quorum sensing compounds will allow us to procure a novel antibiotic, and could help establish a similar protocol for other plants in hopes of finding more with these attributes.

Specified Source(s) of Funding: 2011 USDA NIFA Hispanic Serving Institution

**(013) Anti-bacterial Properties of the Annona montana**

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Bacterial pathogenesis and virulence is linked with cell-to-cell communication. Many plants have anti-quorum sensing (QS) compounds, which can inhibit the interaction within the bacterial community and weaken its pathogenicity. These compounds can be used to combat infections by interrupting the signaling pathways between bacteria. This approach of decreasing virulence through quorum sensing inhibition is different than killing or stopping the growth of bacteria because it will not lead to antibiotic resistance. *Annona montana* has been known for producing acetogenin compounds, which have the potential to cure cancer. Some plants and certain parts of plants have more anti-QS compounds than others. Extracts of the leaves, fruit and bark of a mature *A. montana* tree were made using water, 80% methanol, 80% ethanol, absolute methanol, and absolute ethanol. Biomonitor strains for the anti-QS activity *Chromobacterium violaceum*, *Chromobacterium AHL* mutant CV026, *Agrobacterium tumefaciens* and *Pseudomonas aeruginosa* were grown in Lysogeny broth (LB) and LBagar plates. The extracts were tested through disc diffusion assays on the bacteria to determine which part of the tree contained the most potent anti-QS compounds. The bacterial growth was recorded by counting the colony forming units (CFU) on agar plates and using a spectrometer to monitor the growth by recording the OD_{600}. The objective of this study was to find a new source of anti-QS compounds that can be further developed for medicinal purposes.

Specified Source(s) of Funding: 2011 USDA, NIFA Hispanic Serving Institution
Horticultural production is a rapidly developing area of research for the success of long duration NASA space missions. The growth system presently used by NASA for space horticulture utilizes a conventional artificial lighting scheme—i.e., a flat panel of light-emitting diodes (LEDs) situated directly above the plant beds. This results in mutual or self-shading of plants, such that photosynthesis is restricted in the lower canopy and crop yield is reduced. With this in mind, the present work seeks to reduce mutual or self-shading and to maximize yield in densely planted Amaranth beds by optimizing the spatial distribution of LED lighting. Amaranthus tricolor seeds were started in PRO-MIX BX growing media in 5.1 cm trays under T5 high output fluorescent lighting in a lab. After germination, seedlings were moved to one of three lighting treatments utilizing different spatial configurations of red and blue LED lighting strips, each with a photoperiod of 12 hours. In the first treatment (T1), LEDs were arranged such that the source of illumination came from directly overhead. In the second and third treatments (T2 and T3), 60% of the same quantity of LEDs were placed above the plants while 40% were allocated to sidewall or intracanopy configurations, respectively. The data indicated that an intracanopy lighting configuration (T3) increased available light levels for the growing Amaranth without deleterious effects from heat stress. Furthermore, the intracanopy lighting treatment produced crops with increased vegetative biomass, as indicated by leaf size and leaf number as well as plant height. In conclusion, manipulation of crop yield can be accomplished using spatial configuration of lighting with no additional energy inputs or chemical treatments. This investigation is supported by the Hawaii NASA Space Grant Consortium and provides insight into horticultural practices suitable for long duration spaceflight.

Specified Source(s) of Funding: Hawaii NASA Space Grant Consortium

(015) Influence of Artificial Lights on Nitrate and Sugar Contents of Leaf Lettuce

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High nitrate levels of leafy vegetables in diet may be linked to higher incidences of gastrointestinal cancer. This experiment was conducted to determine if different artificial lights influence the tissue nitrate and sugar concentration of leaf lettuce grown hydroponically as well as in pots under light emitting diode (LED), light emitting plasma (LEP) and high pressure sodium (HPS) lamps. The artificial lights were installed in individual cubicles (1 m x 1 m x 1.5 m) lined with fabrics that transmitted less than 3% natural light inside a greenhouse. The photosynthetic photon flux densities (μmol·m⁻²·s⁻¹) inside the light boxes were: 89, 389, 400, and 142 μmol·m⁻²·s⁻¹, respectively, for LED (2:1 mixture of red and blue lights), LEP, HPS, and natural light. Seedlings of 3 different cultivars (Parris Island, Black Seeded Simpson, Rex Rz) of lettuce were anchored on Styrofoam boards floated inside a tub containing 200 ppm N prepared with 20–20–20 commercial analysis fertilizer. In all cultivars, the nitrate level was lowest when plants were grown under LED compared to other lights. Sugar content determined by a refractometer (°Brix) was also lowest under LED, while both LEP and HPS produced highest Brix readings. When plants were grown in a peat-light mix (Sunshine #1) in pots, tissue nitrate levels were about half of those obtained from hydroponic culture using the same nutrient solution. The pattern of nitrate and sugar accumulation also varied by cultivars under the same artificial lights.

Specified Source(s) of Funding: NDDA-SCBG

Wednesday, August 10, 2016

Poster Session—Undergraduate Student 3

(016) Handheld Sensors Application for Fertilizer Management in Landscaping Ornamental Justitia brandegeana

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The over application of fertilizer is becoming too common in nursery production. Many times it is due to the false assessment made on a plant’s nutrient levels based on simple visual analysis. There are alternatives to visual diagnostics such as plant tissue testing and nondestructive hand held sensors. Plant tissue testing can be time/cost ineffective and simultaneously hinder a plant’s health. We will be using non-destructive handheld sensors to obtain qualitative data that correlates nitrogen levels with a plant’s overall health. Nitrogen is an essential component of chlorophyll in plant leaves as well as numerous proteins. Nitrogen is directly correlated with leaf area, leaf weight, and...
were intermediate in their level of return bloom with 33% for 3.5% on single fruited spurs). 'Golden Delicious' and 'GoldRush' de-fruited and 60% on single fruited spurs) while 'Honeycrisp' had the most return bloom distributed on bourses 0.51–2.0 cm long while 'GoldRush' had most return bloom on bourse buds 0.5–2.5 cm long. Among the four apple cultivars, Gala had the highest return bloom (92% on bourses 0.51–2.0 cm long while 'Gold Rush' had most return bloom on bourse buds 0.5–2.5 cm long. Among the four apple cultivars, a wide range in bourse length was measured. Both 'Honeycisp', and 'Gala' had the highest return bloom on bourse buds 0.5–2.5 cm long. 'Golden Delicious' had the highest return bloom on bourse buds 0.5–2.5 cm long. 'Golden Delicious' had the highest return bloom on bourse buds 0.5–2.5 cm long. 'Golden Delicious' had the most return bloom distributed on bourses 0.51–2.0 cm long while 'Gold Rush' had most return bloom on bourse buds 0.5–2.5 cm long. Among the 4 apple cultivars, Gala had the highest return bloom (92% on de-fruited and 60% on single fruited spurs) while 'Honeycisp' had the least amount of return bloom (17% on de-fruited and 3.5% on single fruited spurs). ‘Golden Delicious’ had the most return bloom with 33% for de-fruited treatment and 16% in single fruited of Golden delicious and 40% and 7% in single fruited spurs of ‘GoldRush’.

(017) Bourse Length Distribution and Return Bloom of Four Apple Cultivars

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Factors that affect flower induction in bourse buds are critically important for consistent production of apples. Irregular flowering may lead to inconsistent cropping (biennial bearing) which is a huge challenge for the apple industry. In order to further understand the factors that can exacerbate biennial bearing, this study was conducted to determine the optimum bourse length for flower induction in four apple cultivars. Bourse lengths of two biennial bearing cultivars (Honeycrisp and Golden Delicious) and two regular bearing cultivars (Gala and GoldRush) were measured throughout the growing season. Half the measured spurs were de-fruited at bloom and half carried a single fruit. Among the four apple cultivars, a wide range in bourse length distribution was measured. Both ‘Honeycisp’, and ‘Gala’ had the highest return bloom on bourse buds 0.5–2.5 cm long. ‘Golden Delicious’ had the highest return bloom on bourse buds 0.5–2.5 cm long. ‘Golden Delicious’ had the most return bloom distributed on bourses 0.51–2.0 cm long while ‘Gold Rush’ had most return bloom on bourse buds 0.51–2.5 cm in length. Among the 4 apple cultivars, Gala had the highest return bloom (92% on de-fruited and 60% on single fruited spurs) while ‘Honeycisp’ had the least amount of return bloom (17% on de-fruited and 3.5% on single fruited spurs). ‘Golden Delicious’ and ‘GoldRush’ were intermediate in their level of return bloom with 33% for de-fruited treatment and 16% in single fruited of Golden delicious and 40% and 7% in single fruited spurs of ‘GoldRush’.

(018) Evaluation of Harvest Time on Postharvest Incidence of Red Drupelet Reversion Development and Firmness of Blackberry Cultivars

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Blackberry (Rubus subgenus Rubus Watson) is an increasingly important fruit for fresh-market worldwide. Developing improved cultivars to be shipped and stored is crucial to expand the fruit shipping industry. The University of Arkansas Fruit Breeding Program has been working to resolve major postharvest disorders, with several cultivars released that show good storage potential. A major limitation for shipping blackberry is its ability to maintain firmness in storage. Another important postharvest disorder is incidence of red drupelet reversion, or simply referred to as reversion. Reversion is a disorder in which drupelets change from black to red during storage. It is thought to occur as a result of rapid changes in temperature from harvest to storage. Fruit is often harvested at high temperatures and moved quickly to storage, especially in the southern United States—this is thought to contribute to increased reversion. In this study, five cultivars were evaluated for firmness and incidence of reversion when harvested at 7:00 AM, 10:00 AM, 1:00 PM, or 4:00 PM, which represented increasing temperatures during the day. Fruit were harvested on two dates, and moved immediately to cold storage (5 °C), and stored for 7 days prior to evaluations. Firmness was evaluated by berry compression and drupelet skin penetration measurements and reversion by absence or presence of reversion of berries. Data analysis indicated significance for main effects of cultivar for penetration, and time of harvest for compression and reversion. No interactions were significant. Compression showed significant differences for harvest time with the 4:00 PM harvest having significantly higher mean firmness across cultivars than the other harvest times. Penetration results indicated ‘Prime-Ark® Traveler’ had significantly higher skin firmness compared to other cultivars. Incidence of reversion was lowest at the 7:00 AM harvest time but not different among other times. Further research is necessary on this topic, but evaluation of the influence of harvest time for postharvest evaluations should continue to be examined.

Specified Source(s) of Funding: Bumpers College Undergraduate Research and Creative Project Grants Program

An asterisk (*) following a name indicates the presenting author.
(019) Interspecific Hybridization within *Penstemon* and Their Potential Uses in Urban Landscapes

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Penstemon, with over 270 different species, is among the largest native genera in North America. Commercially acceptable cultivars of both selections within a specific species and Penstemon interspecific crosses are available in both the North American and European markets; however, these cultivars are almost universally lacking in drought and extreme temperature tolerance. These characteristics, as well as colorful abundant flowers and foliage, are found in the endemic Penstemon of the Intermountain West, which is the center of diversity for this genus. For example, Utah has over 70 native species of this genus with different taxa ranging from mat forming habit to others that grow to at least three feet tall and flower colors ranging across reds, blues, whites, purples, and florescent pinks. The vast majority of these taxa demonstrate natural tolerance to drought and temperature extremes found in their native desert habitats. Our research focuses on tapping into these desirable characteristics by preforming wide crosses within Penstemon to develop commercially viable, hardy cultivars for use in urban desert landscape environments. As we have worked with Penstemon, we have successfully produced seed from approximately 30 wide crosses involving 20 unique species during the 2015 growing season. Throughout the Winter 2015–16, we have been attempting germination of the seed although, as could be expected in interspecific hybridization, only a few of these seed are producing viable plants. We currently have three plants from crosses made in 2015 and two plants from crosses in 2014. We have observed that our 2014 wide cross hybrids predominantly exhibit the female plant’s phenotype. This female dominant phenotype in the F<sub>1</sub> has been previously reported; however, the F<sub>2</sub>, sib matings, and backcross generations in these reports have demonstrated segregation of both of the original parent’s characteristics. We are currently unsure why this is. Improving our understanding of why this phenomenon is taking place in Penstemon is one of the objectives of our research and will help us progress in our long-term goal of developing a commercially acceptable, drought tolerant, disease resistant, and summer long flowering habit for urban landscapes. Thus, our future research will focus on making additional wide crosses as well as developing segregating populations of sib-mating, F<sub>2</sub>s, and backcrosses.

Specified Source(s) of Funding: Department of Plant and Wildlife Sciences, Brigham Young University

(020) Delta Absorbance Meter As a Means to Predict and Reduce Incidence of Browning Disorders

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The Delta Absorbance Meter measures the chlorophyll in fruit and has been suggested as a valuable, non-destructive indicator of fruit maturity. Delta absorbance (ΔA) values were measured on ‘Olympic’ Asian pears, ‘Pink Lady’ apples and ‘Granny Smith’ apples for their rate of success in predicting and reducing the incidence of two browning reactions: internal breakdown and storage scald. Internal breakdown involves the browning of the fruit flesh in mature fruit, while storage scald is a browning reaction that occurs in the peel of stored, immature fruit. There was not a clear value that determined if an ‘Olympic’ Asian pear had internal breakdown. An early harvest found that a ΔA value of below 0.6 indicated that fruit had internal breakdown, yet a second harvest one week later was not as effective. For the apple cultivars, ΔA values were measured weekly pre-storage, during September and October, to establish if a clear relationship could be found between ΔA value and storage scald. The two apple cultivars were also assessed for other maturity measurements, such as their starch pattern index. Results of ‘Pink Lady’ and ‘Granny Smith’ apples were inconclusive. For each, the ΔA pre-storage value did not equate to the ΔA post-storage value, nor was there a clear, predictive relationship with that measurement and the percentage of scald on fruit. However, both apple cultivars appeared to lose their scald susceptibility at a starch-pattern index of 4. The Delta Absorbance Meter was determined to be unable to derive a direct link between ΔA values and browning in ‘Olympic’ Asian pears, ‘Pink Lady’ apples or ‘Granny Smith’ apples.

(029) Highlights: A Newsletter Reporting on Trial Gardens and Horticultural Research at the South Mississippi Branch Experiment Station

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Research in ornamental horticulture at the South Mississippi Branch Experiment Station includes variety trials with new annuals and perennials from international companies, All-America Selections (AAS) trials and an AAS Display Garden, commercial plant propagation methods, alternative nursery substrates, aromatic crops, and more. *Highlights* newsletter began in 2014 to keep nursery and landscape professionals, Extension and research personnel, Master Gardeners, horticultural...
suppliers, and home gardeners up-to-date on news from the Trial Gardens and horticultural research at the experiment station. *HighLights* is distributed to subscribers across the United States and other countries, as well as to members of the Mississippi State University Extension Service. The newsletter is published in a one-page, electronic format using an abundance of color photos and a quick-and-easy-to-read format. Readers report enjoying the themed issues, sharing the newsletter with others, and using information to plan purchases of plants materials for both home and commercial use. *HighLights* has also increased attendance at the experiment station’s annual Ornamental Horticulture Field Day in October. Twenty-one issues of *HighLights* were published in 2015. Past issues of *HighLights* are available at http://mafes.msstate.edu/publications/highlights.asp.

(030) Using Paper Bags for Growing Peaches in Backyards
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Production of peaches in backyard gardens is extremely difficult because peaches are very susceptible to pests and diseases. Pests include plum curculio, thrips, scale, and mites, and diseases include brown rot, peach scab, bacterial spot, and anthracnose. Backyard gardeners typically do not spray or spray very few chemicals, and consequently they are often unsuccessful to produce a crop. The objective of this study was to develop a strategy for homeowners to produce fruit without the need for regular applications of pesticides. The use of paper bags on peaches as they grow on trees is an unconventional method of protecting them from insects and diseases in the United States but is a strategy that has been successfully practiced for many years in Japan, China, Australia, and Spain. Peaches are individually bagged by hand at early stages of fruit development (at thinning, when fruit is thumbnail sized), and paper bags protect the fruit during the rest of the season from diseases, insects, and sunburn. We compared bagged and non-bagged fruit in single-tree experiments and we proved that high-quality peaches can be produced using paper bags with a maximum of two spray applications of chemicals (fungicide + insecticide) available at home improvement stores.

(031) Developing and Implementing the Healthy Virginia Lawns Program
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Extension agents representing nine existing Urban Nutrient Management programs involving Extension Master Gardener volunteers met for a series of meetings with Extension Specialists to develop a statewide urban nutrient management initiative. These facilitated meetings were used to glean from existing programmatic resources to create a new turnkey program kit to support new Extension units wanting to establish the program. Also, with the assistance of a social marketing company, OpinionWorks, we also developed a new name for the initiative: Healthy Virginia Lawns. We hosted an in-service training to introduce agents, local coordinators, and interested Extension Master Gardener volunteers to this new initiative. The overall purpose of this initiative is to equip homeowners with a certified nutrient management plan and information they need to properly manage their residential turf using best management practices to prevent excessive nutrients from entering the Chesapeake Bay Watershed. One goal of the initiative is to teach homeowners how to properly apply appropriate nutrients at the appropriate time of year in the appropriate amounts to their landscapes, primarily turf. This project has been funded by a grant from the Virginia Department of Conservation and Recreation.

Specified Source(s) of Funding: Virginia Department of Conservation and Recreation

(032) Establishing an Extension Floral Design Program
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Mississippi’s Gulf Coast region is home to over 150 commercial nurseries/turfgrass operations as well as being a certified retirement region. In July 2015, Mississippi State University (MSU) Coastal Research & Extension Center began an Extension floral design program. Three programs were developed under client headings of growers, florists and amateur florists toward building awareness of program offerings. The first program area was a series of monthly workshops targeting garden club members, Master Gardeners, and those with special interest in floral design. These basic to intermediate workshops included: arrangement, wreath arrangement, Thanksgiving buffet design and holiday foliage arrangement. Evaluation instruments were devised augmenting standardized MSU Extension forms with questions about the most important thing participant learned, how they heard about workshop, best days and times to attend a workshop, appealing topics and interest in a new certificate floral design program. A second program area offered educational outreach to professional florists. Through site visits to local florists and trends in wedding floral design, a flower crown workshop was developed. The initial session was canceled due to lack of response, then offered again in January at 75% room capacity. Based upon evaluation survey findings, workshops offering wedding and sympathy floral design technical information were developed and offered, including floral surrounds for cremation urns altar and buffet design mechanics lab, corsages and boutonnieres, and a two-day wedding floral workshop. The third of three programs sought to make participants aware of alternative crops and value-added floral products that can be grown and produced in Mississippi. Past studies and buying habits suggest that Mississippians would purchase Mississippi-grown floral materials.
if they were available. A series of floral design demonstrations held at MSU research and extension centers, farmers markets and other venues drew attention to cut foliage, flowers, vines and value-added designs to stimulate commercial production. Programming advertisements were made through a dedicated Facebook page, Coastal R&E Center Facebook page, garden club networks, local television appearances, radio and television announcements, MSU Extension offices and agents email, fliers and handouts. An on-site scientific lab was repurposed into a floral studio able to accommodate eight participants and instructor.

(033) Factors That May Influence the Purchasing Behavior of U.S. Consumers in Relation to Bioplastic Plant Containers

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The horticulture industry is reliant on nonrenewable, petroleum-based containers for growing and selling plants. Although a limited infrastructure exists for recycling such containers, the reality is that over 95% of nonrenewable plant containers end up in landfills. Our team has been developing and testing biorenewable, bioplastic plant containers as alternatives to petroleum-based containers, and is interested in factors that may influence the market for different versions of these sustainable containers. We developed a survey tool that would help us answer the following questions: 1) are consumers likely to purchase plants in bioplastic containers; 2) for which container attributes are consumers more likely to pay extra; and 3) which factors may be predictors for likelihood to purchase and willingness to pay extra for plants in different bioplastic container types. In May 2015, we used the Survey Monkey Audience™ tool to survey a subset of the U.S. adult population with an interest in gardening. We received 1524 usable surveys from all major geographic regions of the United States. Most respondents were between 25 and 64 years of age (91.5%; n = 1394) and were white (81%; n = 1234). Seventy percent (n = 1067) were homeowners, and 63% (n = 960) were female. Over half (51%; n = 777) had household incomes under $50,000 annually, with a range from under $25,000 to over $200,000. More than three-fourths of respondents (77%; n = 1180) had at least some college experience. Our results suggest that greater than 90% of gardening consumers would purchase plants in bioplastic containers if they were available. Most consumers would be willing to pay a premium (extra amount) for plants grown in bioplastic containers, but the premium amount varied based on container type and characteristics. The premium that consumers would pay for plants in containers that provide a fertilizer effect was greater than the premium they would pay for plants in containers that biodegrade in soil or that decompose under composting conditions (P < 0.005). Containers that are compostable, but not biodegradable in soil, were less popular than other bioplastic container types, but will appeal to a niche market comprised of “environmentally sensitive” consumers. Along with improving sustainability of the industry, use of bioplastic containers may provide a greater profit margin by fetching a price premium above that of plants grown in standard petroleum-plastic containers.

Poster Session—Fruit Breeding

(161) Rosbreed: Enabling Marker-assisted Selection for Postharvest Deterioration in Peach

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Peach is a commercially important fruit, second only to apple in terms of temperate fruit tree production. Consumer and market demand is for juicy, firm, flavorful fruit that maintains appealing flesh throughout cold storage. However, peaches often decline in quality after harvest, resulting in reduced consumer acceptance. Developing new peach cultivars using traditional breeding methods can take 15–20 years for the release a new cultivar with improved characteristics. For this reason, the discovery and implementation of marker-assisted breeding holds great promise as a significant mitigation strategy to offset the temporal burden of cultivar development. This project represents a national collaborative effort among peach breeding programs at Clemson University, the University of Arkansas, the University of California, Davis, and Texas A&M University to perform standardized postharvest analysis and to identify appropriate genetic markers associated with postharvest performance in peach. In particular, symptoms of “chilling injury” during cold storage are the focus of initial phenotyping. Further, this phenotypic information will be combined with genotypic data in accordance with the overall goals of the RosBREED initiative. Results from the first year of the standardized post-
harvest phenotyping protocol are discussed.

**Specified Source(s) of Funding:** Combining disease resistance with horticultural quality in new rosaceous cultivars is provided by the Specialty Crop Research Initiative Competitive Grant 2014-51181-22378 of the USDA’s National Institute of Food and Agriculture.

(162) Development of a Standardized Phenotyping Protocol for Blackberry

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The beginnings of DNA-informed breeding for blackberry are underway, with a DNA fingerprinting method being developed for confirming identity by descent. With this movement toward molecular methods, the quality of phenotypic data must be high enough to complement genetic resolution and also be shared amongst breeding programs effectively. Previous protocols for phenotyping have been established under the USDA-Specialty Crop Research Initiative (SCRI)-funded RosBREED I project for apple, peach, strawberry, and sweet and tart cherry. Blackberry is one of several Rosaceous crops included in the SCRI-funded RosBREED II: “Combining Disease Resistance with Horticultural Quality in New Rosaceous Cultivars,” and phenotyping for quality is an objective of this project. In an attempt to optimize commercial relevance, heritability, precision, and standardization with cost and labor efficiency, 17 traits were selected for analysis in this blackberry phenotyping protocol, with an emphasis on fruit quality. Plant traits include cane characteristics, presence or absence of thorns, plant health and vigor, flowering characteristics, and productivity. Fruit characteristics include berry weight, length and width, drupelet diameter, and firmness. Fruit compositional traits include soluble solids content (SSC), pH, and titratable acidity (TA). The phenotyping protocol was used to characterize seedling populations from the University of Arkansas (UA) and USDA-ARS, Oregon breeding programs. Preliminary data analysis of the implemented protocol revealed some findings, particularly in the area of compositional analysis. Analysis of SSC indicated that on average, the USDA-ARS populations had higher SSC compared to UA, with mean values ranging from 10.8% to 13.8% and 8.9% to 11.0%, respectively. In contrast, pH measurements indicated that USDA-ARS populations had lower pH than UA populations, pH mean values ranging from 3.6–3.9 and 3.95–4.2, respectively. TA in USDA-ARS material was more variable and generally higher, with mean values ranging from 0.9% to 2.0% compared to 0.6% to 1.2% for UA material. Crosses between UA and USDA-ARS parents were represented by three populations: two in Oregon (ORUS 4540 and ORUS 4674) and one in Arkansas (Ark_Pop1261). The greatest difference between these populations could be observed in average SSC, where ORUS 4540 and ORUS 4674 exceeded Ark_Pop1261 by 3.0 and 4.1%, respectively. The protocol will continue to be used and further refined in future phenotyping.

**Specified Source(s) of Funding:** Combining disease resistance with horticultural quality in new rosaceous cultivars is provided by the Specialty Crop Research Initiative Competitive Grant 2014-51181-22378 of the USDA’s National Institute of Food and Agriculture

(163) Parentage Verification of Blackberry Seedling Populations with a Microsatellite Fingerprinting Set

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In an effort to confirm identity by descent, seedling populations representing important blackberry (Rubus) breeding parents from the University of Arkansas (UA) and the USDA-ARS, Oregon were analyzed for trueness-to-type with a fingerprinting set consisting of six trinucleotide-containing simple sequence repeats (SSRs). Six seedling populations from UA and 12 seedling populations from USDA-ARS were initially genotyped with this 6-SSR set. Presence of alleles not found in either parent but in a seedling indicated an off-type individual. This initial analysis with the 6-SSR set revealed 19 off-type seedlings out of 264 from UA and 24 off-types out of 202 seedlings representing 11 USDA-ARS populations. In the 12th population, ORUS 4647, all 23 seedlings contained alleles found in one of the parents, ‘Obsidian’, but also contained an allele not found in either ‘Obsidian’ or ORUS 2532-1, possibly indicating that the wrong parent plant was sampled for ORUS 2532-1. This hypothesis will be confirmed by genotyping each of the three available ORUS 2532-1 plants. Though the 6-SSR set was able to identify some off-types, it could not differentiate amongst 23 groups of individuals representing 55 seedlings from the
UA populations and seven pairs of individuals representing 14 individuals from the USDA-ARS populations. To achieve better resolution, marker RH_MEa0016bC11 was removed and replaced with RH_MEa0008cF01, and two additional markers were added, resulting in a more polymorphic 8-SSR fingerprinting set. With this revised set of primers, undifferentiated samples were reduced to eight in UA material, and there was no reduction for the USDA-ARS material. Genotyping the 14 undifferentiated USDA-ARS samples with 13 additional Rubus SSRs generated similar results for 12 of the samples, indicating good distinguishing ability of this 8-SSR multiplex. This 8-SSR multiplex can be used in future work as a quick screen to confirm parentage in blackberry and ensure that progeny are true to type and that any genetically redundant individuals are excluded.

Specified Source(s) of Funding: Combining disease resistance with horticultural quality in new rosaceous cultivars is provided by the Specialty Crop Research Initiative Competitive Grant 2014-51181-22378 of the USDA's National Institute of Food and Agriculture.

(164) RosBREED: Enabling Marker-assisted Breeding for Brown Rot (Monilinia spp.) Resistance in Peach

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Brown rot, caused by Monilinia spp., is one of the most important diseases of stone fruits. The fungus mainly infects blossoms and fruits, and can result in significant yield losses. Estimated yearly cost to the U.S. stakeholders for chemical protection against bloom blight and pre- and postharvest fruit decay is $170M. Although some degree of resistance has been found in the Brazilian cultivar Bolinha and some cultivars and advanced selections developed in the University of California, Davis (UC Davis) and USDA breeding programs, genetic resistance to brown rot in peaches is still lacking. In commercial peach production, the two phases of the disease (blossom and fruit infection) can only be controlled with routine fungicide applications, which cause both environment and fungicide resistance concerns. The RosBREED project, is combining disease resistance with horticultural quality by evaluating sources of brown rot resistance/high tolerance in peach germplasm and enabling pyramiding and combining resistant alleles in fresh market and processing peach. Phenotyping protocol, developed at UC Davis, includes controlled laboratory inoculation of unwounded and wounded peach fruit on a panel of peach breeding germplasm. The next generation of peach cultivars with superior horticultural quality and disease resistance/tolerance will reduce the human health risks and environmental costs associated with pesticides load in the agro-ecosystem. Consumers will benefit from greater access to a more stable supply of nutritious fruit with superior eating qualities that will translate into increased per capita consumption and improved human health and wellbeing. Preliminary results from the first year of this study will be presented and discussed in detail.

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(165) Breeding Activities on Pomegranate at the CREA-Fruit Tree Research Center, Rome, Italy

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Pomegranate cultivation has considerably increased worldwide during recent years, mainly in reaction to the rising consumers’ awareness on the numerous nutraceutical benefits of this fruit. To satisfy also future demands, research will be even more necessary, both concerning modernization of cultivation systems and the set of available varieties. The management of vegetative and productive behavior of this species is not easy, especially because of its intensive suckering tendency and shrubby growth habit; therefore, in 2002, the CREA-FRU has initiated a breeding program based on crosses and selections, targeted at the individuation of non-suckering rootstocks and selections presenting a growth habit which is more suitable for modern orchard management. In 2012, we selected the first non-suckering Punica granatum rootstock, for which the European Community Plant Variety Right (CPVR) was applied in December 2015, under the breeder reference name PJK2014. This rootstock can easily be propagated by using hardwood cuttings, while no hormonal treatment is needed. Grafting tests with the main known cultivars were very successful. Concerning fruit quality, the present assortment of cultivars does not fully meet consumers’ expectations who are demanding for high quality products for fresh use (arils) and transformed derivatives such as juices, jellies and jams. In order to meet these expectations, the CREA-FRU initiated a breeding program targeted at the development of new varieties for fruit quality under different aspects. Specific objectives of these activities are the improvement of organoleptic qualities (high sugar/acidity ratio), high juice content, soft pink or red arils, as well as new fruit shape and
colour, early ripening, long shelf life and promising postharvest performance and low sensibility to fruit cracking. Concerning plant habit, genotypes showing an evenly spreading canopy with strong branches and thornless twigs are preferred. The basic material for these breeding lines was provided by two different populations, one of Mediterranean origin and the other from the Near East, both exhibiting considerable phenotypic variability, but generally speaking, the first one having scarcely colored fruits and low acidity, the latter one with intensively colored fruits but high levels of acidity. We obtained 20 selections with agronomically and pomologically interesting and innovative characteristics compared to the cultivars which are currently available on the market: bright red, black or dark brown skin, intensely soft pink or bordeaux-colored arils, and plants with standard growth habit or dwarf, without spines and high productive capacity.

Poster Session—Genetics and Germplasm 2

(119) Transcriptional Landscape of the Apple Shoot Apex

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The regulation of floral initiation in woody perennial plants, such as apple, is a complex pathway that has previously been studied only at the physiological level. The lack of knowledge about underlying molecular mechanisms has limited the ability to manipulate flowering to overcome production problems such as juvenility, over-cropping and alternate bearing. Here, we analyzed gene expression patterns associated with floral initiation in apple through transcriptional profiling of a seasonal developmental gradient of the shoot apical meristem. We also characterized the flowering-promotive effect of fruit removal and flowering-repressive effect of applied gibberellins (GAs) on gene expression. Our resulting data, containing nearly 1E11 bases of transcribed genes, represents one of the most comprehensive analyses of gene expression associated with floral initiation in a woody perennial plant to date.

Specified Source(s) of Funding: Michigan Apple Commission and Michigan AgBioResearch

(120) Identification of Differentially Expressed Genes for Mummy Berry (Monilinia vaccinii-corymbosi) Resistance in Blueberry

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With an increasing consumer focus on healthy eating habits and antioxidant intake, blueberries are steadily rising in sales, and by consequence, are also increasing in the amount of agricultural land they cover. More cultivars continue to be developed, with particular interest in traits for fruit firmness, allowing for mechanical harvest, early or late fruit ripening for longer spans of local availability, and the classical trait of interest, yield. However, with an increased amount of acreage comes an increase in the prevalence of certain diseases. One of the most devastating diseases of blueberry (Vaccinium corymbosum and V. virgatum) in the United States is mummy berry. The causal fungus of the disease is Monilinia vaccinii-corymbosi. The disease was first reported in Europe in 2002 and has become important in Europe since then. Crop loss due to mummy berry has been reported repeatedly from 1960s until now. In 1969, growers in British Columbia, Canada lost 8.1% of their crop due to mummy berry estimating $750,000. Back in 1974, New Hampshire’s blueberry producers lost 70% to 80% of their crop. In 2002 in no-spray rabbiteye blueberry fields in North Carolina, 70-80% of crop loss was reported. Current methods of controlling the disease are including cultural practices and chemical controls. Developing resistant cultivars not only reduces the cost of fungicide application(s), but also is an environmentally friendly measure to control the disease. Complexity of the disease and long juvenility life of blueberry hampers the breeding efforts. Our knowledge about the mode of action of the pathogen and its interaction with the plant is very limited. In order to identify genes that are differentially expressed in response to the disease, we used an untreated and a treated susceptible blueberry cultivar, Arlen, for gene expression analysis of mummy berry pathogen infection. A total of 16 barcoded RNA-Seq libraries of leaf, flower, and fruit tissues were constructed and 24 million raw reads (150 bases long, single-end) equivalent to 3.6 Gb of nucleotides were generated. The reads were mapped to the blueberry reference genome to identify differentially expressed genes and a genome guided transcriptome assembly of blueberry was made. The implication of leveraging RNA-Seq technology in identification of differentially expressed genes will be discussed. This work could lead to development of molecular marker that can be used in marker-assisted selections for genomic selection and new cultivar development.

(121) Genetic Diversity of the North American Wild Kidney Bean (Phaseolus polystachios) in the Eastern United States

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North American wild kidney bean or thicket bean (Phaseolus polystachios (L.) Britton, Sterns, & Poggenb) is a perennial vine found in the eastern United States from Texas to Connecticut. It is the only Phaseolus species native to temperate North America. Its closest cultivated relative is P. lunatus, the lima bean. Urbanization, agricultural development, and habitat destruction have caused a decline in populations, leading to widely varying...
estimates of conservation status across its distribution: e.g., it was once prevalent in the Detroit River International Wildlife Refuge, but has not been seen there since the late 1800’s. Crop wild relatives are a critical source of genetic diversity, often holding untapped genes for breeding of domesticated plants in agriculture for disease resistance, yield, quality, and adaptation to climate change, as well as ecologically important members of natural habitat. The Western Regional Plant Introduction Station of the National Plant Germplasm System holds over 20,000 accessions of Phaseolus from 47 species but had only 13 accessions of the wild Phaseolus polystachios, 6 of which had recently been collected in Florida. A collection trip throughout the Midwest in 2015 acquired populations from Missouri (1), Indiana (2), Ohio (7), and West Virginia (1). In Missouri, Illinois, and Indiana, information leading to 15 historically collected sites, resulted in finding only four of these populations still existing. Amplified fragment length polymorphism (AFLP) molecular analysis showed each population to be genetically distinct and distinct from the previous populations from Florida. Several of the populations were infested with weevils, reducing seed viability and threatening population survival. Populations are currently being regenerated for distribution for research and breeding. Plans are underway for future testing for resistance to white mold (Sclerotinia sclerotiorum). Population diversity from the Eastern states from Florida to New England and the Midwest and coevolution with white mold may have resulted in new sources of resistance for interspecific breeding, especially with P. lunatus.

(123) Phenotypic Variability in Non-grafted UCB-1 Pistachio Rootstock
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Most pistachio rootstocks are currently F1 seedlings from controlled inter-specific crosses. These F1 seedlings are genetically variable because of the inherent heterozygosity of both parents. UCB-1 is a seedling rootstock that is widely used in commercial pistachio production. It’s parents are P. atlanticus x P. integerrima. In 2013, 960 UCB-1 seedlings were planted near Davis, CA, followed by an additional 264 seedlings one year later. This population is being used to investigate the UCB-1 phenotypic and genotypic variation and to look for superior UCB-1 individuals that might be used as clonal rootstock. Phenotypic measurements began after the first growing season, in January 2014. Data included, tree height, trunk caliper, and branching. There was high phenotypic variation in the planting. Tree height and caliper were weakly correlated during the first two growing seasons. The genomes of the parent trees and UCB-1 seedlings are being assembled and genotyping-by-sequencing of the whole population is underway. These genetic and phenotypic data will be combined to determine the genetic basis of stunting of some trees grafted onto UCB-1 rootstock.

(124) A Field Evaluation of Buxus Cultivar and Species Germplasm
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Boxwood (Buxus sp.) is one of the oldest cultivated ornamental plants, with first use of the plant noted in Egypt around 4,000 BCE. Currently, approximately 70 Buxus species are recognized. Boxwoods naturally occur in three regions in the world; southern Europe extending into the Caucasus, N. Africa and Iran, northern South America, Central America, Mexico and islands in the West Indies, and East Asia in the Himalayas, China, Korea and Japan. Given the largely (sub)tropical distribution of the species, most Buxus cultivars receive winter hardiness ratings no harder than USDA Plant Hardiness Zone 5 (−23 °C to −28.9 °C). In an effort to identify genotypes hardy in Zone 4 (−28 °C to −34.4 °C) landscapes, a collection of 17 Buxus cultivars and species accessions were evaluated in two replicated field plantings in Chanhassen, MN, from 2007–16. Plants were established in the field in randomized complete block designs with each genotype replicated in the plantings four and three times, respectively. Other than occasional irrigation in the summer of planting, wood chip mulch, hand weeding and occasional spot herbicide applications for weed control, plants received minimal care. Data that included winter desiccation damage, plant and leaf size, and presence of leaf edge variegation were collected once per year. In addition, SPAD-50 greenness assays and winter and summer color quantifications of randomly collected leaves from each surviving plant in the trial were conducted using a colorimetric assay of photos taken of the leaves in April and June of 2016. The lowest temperature recorded through the duration of the trial was −32.2 °C (2009), while the highest winter low temperature was −24.4 °C (2012). The average low winter temperature for the nine years of the trial was −28.4 °C, which is commensurate with a USDA Plant Hardiness Zone 5A winter. No plant deaths were recorded for five genotypes in the study, and at least one plant survived for each genotype. All of the genotypes had plant(s) that suffered greater than 30% desiccation injury in at least one winter. However, three cultivars exhibited less than 15% death and/or damage over reps, plots and years. Based on growth, cold damage sustained over the duration of the trial and winter and summer leaf color assessments, ‘Wilson’s Northern Charm’, Green Ice®, and Chicagoland Green® were rated as the best boxwood cultivars for USDA Zone 4 landscape use.

An asterisk (*) following a name indicates the presenting author.
Notes on Citrullus spp. and Acanthosicyos naudinianus

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Scanning electron microscopy and light microscopy were used to examine pollen of the currently recognized species (and forms) within the genus Citrullus (Cucurbitaceae). Materials examined included: C. lanatus (Thunb.) Matsum. & Nakai including the citron (C. amarus Schrad.) and egusi (C. lanatus subsp. mucospermus Fursa) forms, C. colocynthis (L.) Schrad., C. rehmmii de Winter, C. ecirhosus (Cogn.) and a member of a closely related genus, Acanthosicyos naudinianus (Sond.) C. Jeffrey (Citrullus naudinianus (Sond.) Hook. F., Cucumis naudinianus Sond.). Pollen of all species and forms were similar in shape differing slightly in their width (W), length (L) and L/W ratio. In general, all were characterized as prolate and tricolpate with a small polar area and reticulate ornamentation. A mutant effecting pollen ornamentation was identified in PI 482261, a citron type from Zimbabwe. Pollen ornamentation on PI 482261 was rugulate. An examination of 15 additional accessions from neighboring areas in Zimbabwe revealed a second mutant of this type in PI 482312. Mutations of this sort could be used to facilitate studies of pollen transmission in this genus. Artificial hybridizations (2) between C. colocynthis (PI 482261) x A. naudinianus (GRIF 14032) produced 84 seed from two fruits. The seed were subsequently germinated in vitro and the seedlings (21) acclimated to greenhouse conditions. The F1 hybrids exhibited the zig-zag growth pattern of the stem typical of the male parent and other characteristics of the male parent such as the presence of solitary tendrils and storage root formation. These preliminary data indicate a relatively close relationship between A. naudinianus and C. colocynthis and suggest that introgression of traits such as the drought tolerance, frost tolerance, storage root formation and other characteristics associated with A. naudinianus (Gemsbok cucumber) to C. lanatus may be possible using C. colocynthis as a bridge species.

Fish Hydrolysates Improve Growth of Containerized Lettuce

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The use of fish hydrolysates to improve soil fertility and enhance crop yield has gained considerable momentum due to its contribution to agroecological sustainability. Short-term (30-days after transplanting) effects of fish hydrolysates, applied as drench (3 ml of fish hydrolysates at 0, 14, and 24 d after transplanting), on romaine lettuce plants (Lactuca sativa L. cv. Heart’s Delight)
were evaluated in a growth chamber. Fish hydrolysate treatment improved soil fertility and increased lettuce shoot fresh and dry mass (FM and DM), stem diameter, leaf number and root DM. It also increased leaf chlorophyll a, b and total contents but had no effects on leaf photochemical efficiency, yield and electron transport rate. In addition, fish hydrolysate treatment improved lettuce quality by increasing leaf succulence. The results suggest that fish hydrolysate could be utilized for lettuce organic production to enhance its yield and quality.

(217) Optimized Light Quality and Fertilizer Composition for Crop Production on the International Space Station

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Producing fresh food will be essential in order to supply optimal nutrition for astronauts at distant space destinations. Efficient practices for sustainable production of leafy greens in space are currently being studied on the International Space Station (ISS). Providing adequate light quality, quantity, and fertilizer formulations will be a significant challenge for production of salad crops in space. The ISS currently houses the “ Veggie,” a small, modular, light emitting diode (LED)-based plant-growth unit developed by the Orbital Technologies Corporation (ORBITEC). Veggie analogs (VAs) have been developed by ORBITEC and are being utilized for ground-based testing in growth chambers at both the Kennedy Space Center and at Purdue University to mimic the carbon dioxide, humidity, and temperature environments of the ISS. These VA units include an LED light cap and a passive irrigation system that allows plants grown at 1xg to be compared with those grown in microgravity. Studies demonstrate that the use of red + blue LEDs can provide sufficient quality and quantity of photosynthetically active radiation, whereas incorporating green LEDs creates deeper plant-canopy light penetration and aesthetic appeal as plants appear greener. Optimized spectral composition and fertilizer ratios for crop species down-selected by NASA have yet to be determined. In this study, Chinese Cabbage (Brassica rapa cv. Tokyo Bekana) was grown for 28 days in a soilless medium consisting of 75% arcillite (calcined clay) + 25% vermiculite using 100 or 180 day slow-release, polymer-coated 18-6-8 N-P-K fertilizer in three different ratios: 100% 180, 66% 180 + 34% 100, and 50% 180 + 50% 100. Four different light-quality treatments were analyzed with three different ratios of red and blue light: 82% R + 9% B, 64% R + 27% B, 45.5% R + 45.5% B, and one split treatment using 82R:9B for 21 days and 45.5R:45.5B for the remaining 7 days. All treatments were supplemented 9% green light with a combined total PPF of 330 µmol·m–2·s–1 when measured from the central point of the growth area. A passive irrigation system replenished transpiration water losses from a wicking reservoir. Plants grown under more red-dominant light exhibited more biomass accumulation than other treatments. Light quality had a stronger impact on plant growth and development than did fertilizer quality. Jointly funded by the Human Research Program and Space Biology in the ILSRA 2015 NRA call under grant NNX15AN78G.

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(219) Controlled-release and Water-soluble Fertilizers Affect Growth and Tissue Nutrient Concentrations of Basil, Dill, and Parsley

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Limited information is available for fertilizing containerized herbs to produce appropriately sized plants with adequate tissue nutrient concentrations. The objectives of this research were to quantify growth and tissue mineral nutrient concentrations of containerized culinary herbs fertilized with water-soluble (WSF) or controlled-release fertilizer during production. Seedlings of ‘Italian Large Leaf’ basil (Ocimum basilicum L.), ‘Fernleaf’ dill (Anethum graveolens L.), and ‘Giant Parsley of Italy’ parsley (Petroselinum crispum Mill.) were transplanted into 10.4-cm diameter containers filled with soilless substrate comprised of (by vol.) 75% sphagnum peat moss and 25% perlite containing 0, 1, 2.5, 5, or 10 lb/yd3 CRF fertilizer (16–2.2–16.6); plants with CRF were irrigated immediately at transplant, plants with no CRF were provided with 0 (control), 50, 100, 200, or 400 mg·L–1 N from a complete, WSF fertilizer (21–2.2–16.6); plants with CRF were irrigated with clear water. Data collected included height, widest width, and perpendicular width. Growth Index (GI) was calculated. Plants were harvested at the substrate surface, plants were weighed, fresh mass was recorded, shoots were then triple-rinsed in deionized water. Shoots were then dried and shoot dry mass (SDM) was recorded. Dried shoots were submitted to a commercial laboratory for nutrient analyses. Within each species, untreated control plants had smaller GI, SDM, and lower tissue N levels than plants at all other fertilizer levels and sources. Differences in GI across non-control treatments occurred for basil and parsley, though fewer differences were observed for parsley. For example, basil supplied with 200 mg·L–1 WSF were 33% larger than plants supplied with 50 mg·L–1 N. Conversely, parsley supplied with 200 mg·L–1 N were similar to plants grown with 50 mg·L–1 N, while no differences in GI were observed among fertilized dill plants. Fresh mass of dill treated with 10 lb/yd3 CRF (14.0 g) was similar to 50 and 100 mg·L–1 N (13.7 and 13.7 g, respectively). Alternatively, basil supplied with 10 lb/yd3 CRF were 32% and 19% larger than plants treated with 50 and 100 mg·L–1 N, respectively. Tissue N, P, and K concentrations were within or above recommended ranges for all species supplied with 5 and 10 lb/yd3 CRF and 200 and 400 mg·L–1 N, respectively.

An asterisk (*) following a name indicates the presenting author.
though there were no visible symptoms of nutrient deficiencies for plants provided with less fertilizer. Producers should use this information to select appropriate fertilizer concentrations for containerized basil, dill, and parsley production.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation

Poster Session—Human Issues in Horticulture

(063) Certified Horticulturist Exam for CEA/ GH Greenhouse Is Crucial for ASHS

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Certified Horticulture (ASHS-CH) is widely accepted for minimum standards for experiential horticulturists. The current program focuses on outdoor production, lacking controlled environmental agriculture (CEA) and/or greenhouse management issues. Controlled environmental agriculture and greenhouse production is on the increase due to legislation surrounding medicinal and recreational Cannabis sativa (L.) production. An ASHS-CH CEA or CH-GH could become an indoor standard for horticulture practice. Federal, state, and local regulators and cultivation managers would benefit by knowledgeable staff that meet expectations yet may move to emerging production states. The current program should be retained but perhaps renamed ASHS-CH-L.

Specified Source(s) of Funding: Otoke Horticulture, LLC

(064) Chainsaw Safety Training for Landscape and Tree Care Workers

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In the past four years we have successfully trained 4174 landscape workers in safety and other topics. In 2015, we expanded the training program to include tree care workers. The training sessions focused on chainsaw safety. The chainsaw is arguably the most dangerous tool used in the landscape and tree care industries. Landscape workers use it occasionally; tree care workers may use it daily. Landscape workers risk accidents from inexperience, tree care workers from confidence. Both landscape and tree care workers tend to be visual and hands-on learners. Demonstration and picture-rich training materials are important for both. Peer-to-peer training and the street credibility of the trainer are also very important for both groups. Despite these similarities, training programs for the two groups quickly diverged. Large landscape companies are keenly interested in safety training and eager to host training onsite, while large tree care companies have strong internal safety training programs and little interest in external trainings. Small and mid-sized landscape companies can be reached via state industry associations (the Urban Ag Council and the Georgia Green Industry Association). There are no comparable state tree care associations (the Georgia Arborist Association brings together tree care professionals and tree enthusiasts, but lacks a business focus). Though it is relatively easy to draw participants in both groups who are interested in continuing education credits, these participants were often middle managers, rather than workers. Landscape companies were not willing to send workers to all-day trainings and asked that trainings be shortened. Small to midsized tree care companies were willing to send workers to all day trainings. Landscape companies suggested pole saw safety be included and were far more interested in ladder safety than tree care companies. Despite effort, we were not able to connect with Hispanic tree care workers and trainings held in Spanish were canceled due to a lack of interest. Very few Hispanics participated in the English trainings. It remains to be determined if the low Hispanic turnout resulted from reliance on online marketing efforts, the seasonality of tree care workers, or employer preference. Public sector managers and employees expressed far more interest in chainsaw safety than landscape safety. Buy-in from business owners and management is critical to successful worker training programs. Because management needs are as critical as training content, the chainsaw safety program diverged into two distinct programs.

Specified Source(s) of Funding: Susan Harwood Training Grant, OSHA DOL

Poster Session—Organic Horticulture 2

(240) Impact of Soil Amendments on Organosulfur Compounds in Onion

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Onion is most widely cultivated species of the genus Allium. Onion is valued as food and medicine primarily for the flavor and medicinal properties of its organic sulfur compounds. A field study was conducted at Kentucky State University (KSU) Research and Demonstration Farm. The soil in five plots was mixed with sewage sludge, five plots were mixed with yard-waste compost, five plots were mixed with laying hen manure each at 15 t/acre, and five unamended plots were used for comparison purposes. Plots were planted with onion, Allium cepa L. var. Super Star-F. The objectives of this investigation were to: i) determine the concentrations of organosulfur compounds (dipropyl disulfide and dipropyl trisulfide) in onion

An asterisk (*) following a name indicates the presenting author.
bulbs and ii) investigate the effect of soil amendments (sewage sludge, yard-waste, and chicken manure) on the concentration of sulfur compounds in onion bulbs. Gas chromatographic/mass spectrometric (GC/MS) analyses of onion oil in chloroform extracts revealed the presence of two major fragment ions that correspond to dipropyl disulfide and -trisulfide. Concentration of these two organic sulfur compounds was greatest (1.5 and 0.8 mg/100 g fresh weight, respectively) in onion bulbs of plants grown in chicken manure and lowest (0.4 and 0.07 mg/100 g fresh weight, respectively) in onion bulbs of plants grown in yard-waste compost treatments. We concluded that chicken manure could be favorably utilized in growing onions with health-promoting properties.

Specified Source(s) of Funding: USDA/CSREES

(085) Yield Potential of Fourteen Organic Sweetpotato Cultivars Grown in Various Mulches

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A field experiment was conducted on fourteen cultivars of organic sweetpotato at the Tennessee State University Organic farm in summer 2015 growing season. Cultivars ‘Beauregard’, ‘Porto Rico’, ‘O Henry’, ‘All Purple’, ‘Carolina Ruby’, ‘Ginseng’, ‘Murasaki’, ‘Covington’, ‘Centennial’, ‘Japanese Purple’, ‘Burgundy’, ‘Hernandez’, ‘Old Yellow’ and ‘Orleans’ were grown in raised beds in three mulch treatments black plastic, wheat straw, pine needle and no mulch (control) using a complete randomized block design with four replications. Experimental plots were drip-irrigated and maintained in organic management system as per standards of National Organic Program. Two applications of organic fertilizer were applied during the crop cycle and data collected on the yield, length, weight and diameter of the roots. The total, marketable and cull yields varied significantly (P < 0.05) among the cultivars, however there was no significant difference in yield between the mulch treatments tested. The total yield was highest in ‘Carolina ruby’ (34,790 lb/acre) and the least culls observed in ‘All Purple’ cultivar. In the group consisting of ‘Ginseng’, ‘Carolina Ruby’, ‘Old Yellow’ and ‘Hernandez’ varieties, the highest mean weight of roots grown was measured in the wheat straw mulch bed (15.60 oz), which was significantly higher than the plastic mulch with least root weight (11.19 oz). In the group consisting of ‘Orleans’, ‘Murasaki’, ‘Covington’, ‘Japanese Purple’, ‘Burgundy’ and ‘Centennial’ the heaviest root and longest length was recorded in the plastic mulch (18.92 oz and 6.9 cm) and the least root weights and length was in the pine needle mulch (15.27 oz and 5.66 cm). These preliminary findings suggest that mulches can influence the weight, length, and diameter of independent sweetpotato roots.

Specified Source(s) of Funding: USDA/CSREES

(086) Cultivar Evaluation of Organic Leafy Greens Grown in Greenhouse

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Major vegetable crops benefit from protected cultivation structures like greenhouses, hoop houses, high tunnels and low tunnels. They extend the growth of these vegetables by extending the season. Controlled environmental conditions also help to control the insect pest infestations and harsh abiotic stresses. Leafy greens are small stature crops that can easily be grown inside hoop houses in an off season under the controlled environment. Varietal evaluation trial for 26 varieties of six different organic leafy green vegetables including lettuce, kale, mustard, spinach, swiss chard, collards and amaranths was conducted in Fall 2015 in the greenhouse at Tennessee State University, Nashville. Among the six lettuce cultivars, ‘Buttercunch’ had the highest yield followed by ‘Black-seeded Simpson’ with average plant weights of 455.8 g and 308.9 g, respectively. ‘White Russian’ kale and ‘Tender green’ mustard performed well and had the highest yields with average plant weight of 317 g and 634.6 g/plant, respectively. ‘Golden chard’ of Swiss chard, and the ‘Hop red dye’ of amaranths had the highest yield with average plant weight of 211.0g and 89.0 g/plant, respectively. No significant difference in average plant weight or total yield per acre observed in collard greens. Aphid infestation below threshold level noticed on ‘Red Russian’ cultivar late in the season.

Specified Source(s) of Funding: Evans-Allen

(087) Yield Performance of Twenty-Six Organic Tomato Cultivars Grown in Tennessee

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Organic and heirloom tomatoes (Solanum lycopersicum L.) are high value products with favorable tastes for consumers. Tomato growers select cultivars based on yield resistance to insect pests and disease performance under local soil and climatic conditions. Current information regarding cultivar performance under organic, humid subtropical conditions in the United States remains insufficient. A variety trial of tomato was conducted in summer 2015 growing season at the certified organic farm of College of Agriculture, Nashville campus. Twenty-four cultivars of tomato were grown in the open field under organic management practices as per National Organic Program (NOP) standards. The experimental design was randomized block design with three replications consisting of rows spaced 3’ apart with plants spaced 2’ between each plant within a row. Experimental plots were drip irrigated. Yields ranged from a high of 31.40 tons/hectare for hybrid ‘Arbason’ to a low of 3.88 tons/hectare for ‘Hillbilly’, which is an open pollinated, indeterminate cultivar.

Specified Source(s) of Funding: Evans-Allen
‘Gold Nugget’ (28.18 tons/hectare) and Roma (27.19 tons/hectare) had the higher yields after ‘Arbason’. ‘Cherry Sweetie’ and ‘Bing Cherry’ were high in sugar content (7 °Brix). The study demonstrated that ‘Arbason’ was higher (42%) in yield in beefsteak type, ‘Gold Nugget’ produced higher yields (35%) in cherry type and ‘Roma’ produced higher yields (33%) among 26 varieties grown. No serious issue of insect pest and disease observed. Weeds were challenging in the organic field and kept minimum by manual or mechanical control. The preliminary results suggest some cultivars have high yield potential in organic management system.

**Specified Source(s) of Funding:** Evans-Allen

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### (088) Fruit Yield and Quality of Heirloom Watermelon Cultivars Grown Organically

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Watermelon is a popular fruit vegetable due to its delicious flavor and for being a source of vitamins and antioxidants. Majority of watermelon cultivars used commercially are triploid hybrids that produce seedless fruit. Triploid hybrids were produced by mutations and are not presently acceptable for organic production. There is currently scant information on organic production of watermelon in the southeastern United States. The objective was to evaluate the yield of organic watermelon heirloom cultivars. Experiment was conducted in Tifton, GA, in Spring 2015 in organically certified land. Soil is loamy sand, with a pH of about 6.5. Watermelon was planted on 6 May 2015 on raised beds (1.8-m centers) with drip tape and black plastic mulch. Prior to making the bed, 5529 kg/ha of organic fertilizer (microSTART 3-2-3, Perdue AgriRecycle, LLC) was applied. Cultivars evaluated were: Moon & Stars (Cherokee), Sweet Siberian OG, Mtn. Sweet Yellow, Moon & Stars (VDoren), Petite Yellow, Chris Cross, Chelsea, Moon & Stars (Yellow), Golden Midget, Cream Saskatchewan, and Picnic. Fruit were harvested from 18 June to 14 July 2015. Individual fruit were graded and weighed according to USDA grading standards. Fruit soluble solids (SSC) (measured with a refractometer) and titratable acidity (TA) were determined. Mean seasonal air temperature was 23.5 °C; cumulative rainfall was 114 mm. Marketable yield was highest in ‘Chris Cross’ (58.1 t/ha) and lowest in Petite Yellow (32.0 t/ha). Fruit weight was lowest in ‘Golden Midget’ (2.1 kg) and highest in ‘Chelsea’ (7.3 kg). Soluble solids were highest in ‘Chelsea’ (7.96%) and ‘Mountain Sweet Yellow’ (7.88%) and lowest in ‘Golden Midget’ (4.99%). Titratable acidity was highest in ‘Cream Saskatchewan’ (0.518%) and lowest in ‘Moon & Stars’ (Cherokee) (0.389%) and ‘Golden Midget’ (0.380%). SSC/TA ratio was greatest in ‘Moon & Stars’ (Cherokee) (19.9%). Across cultivars, values of SSC were low and those of TA were high likely because fruit were harvested before reaching ripe stage. However, increased incidence of fruit decay was observed in ripe fruit or as fruit approached the ripe stage. Thus, determination of proper harvest index for heirloom watermelon cultivars is important to maximize fruit quality and reduce postharvest losses.

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### (089) Performance of Twelve Organic Bell Pepper Varieties in the Piedmont of North Carolina

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Bell pepper is an important crop for small farmers as well as consumers in the Piedmont of North Carolina. Hot/humid weather, insect pests, and diseases challenge growing field bell pepper organically in the region. The objective of this trial was to identify better cultivars for organic bell pepper production in the Piedmont. Twelve bell pepper cultivars of various mature fruit color were evaluated in the 2015 growing season. Plants started with seeds in an organic greenhouse on 7 April, and were transplanted into the field on 21 May. Three plots of each cultivar were planted in a completely randomized design. There were 16 plants in each replication that are planted in two rows. The plants were planted into 36-inch wide raised beds covered with black plastic and with one dripline buried under the plastic. Yield and number of fruit varied significantly among varieties. ‘Aura’ had the highest total and marketable yield, 2.29 and 1.71 kg/plant respectively, followed by ‘Sweet Sunrise’ (1.89 and 1.03 kg/plant). ‘Aura’, ‘Sweet Chocolate’, ‘Sweet Sunrise’, and ‘Melina’ reached the full fruit color in 80–85 days; King Crimson, Abay, Sprinter, and Madonna in 86–90 days; and California Wonder, Citrona, and Olympus in 91–95 days. ‘California Wonder’, ‘Madona’, and ‘Olympus’ had large fruit (> 150 gram/fruit), while ‘Abay’, ‘Citrona’, ‘Melina’, ‘Sprinter’, and ‘Sweet Sunshine’ had medium-sized fruit (110–149 grams/fruit). Based on this trial the recommended varieties are ‘Aura’, ‘California Wonder’, ‘Madona’, ‘Melina’, ‘Sweet Chocolate’, and ‘Sweet Sunrise’.

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### (090) Evaluation of Organic Fertilizers on the Growth and Yield of New Mexico Green Chile (Capsicum annuum L.)

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New Mexico’s growers have the opportunity to capitalize on the increasing demand for organic produce with organic green chile production. Conventional growers have numerous commercially
available options for fertilizers in both granular and liquid forms. Organic fertilizers are less available, especially in liquid form. Most conventional growers optimize timing of fertilization by fertigating through drip irrigation. Currently, the standard practices in southern NM for organic chile production is furrow irrigation and fertilization through one pre-plant application of 500 lb/acre of granular, heat-treated chicken manure. Green chile crops usually undergo two harvests and require additional nitrogen application for robust development of second-harvest fruits. Organic growers are not able to apply additional granular fertilizer for the second-harvest because plant size prevents equipment entry into the field. A liquid form of organically sourced fertilizer, like compost tea, may benefit the growth and yield of second harvest crops in green chile production. To determine plant response to organically sourced fertilizers, two hybrid green chile cultivars, G76 (Harris Moran) and Chile 1 (United Genetics), were evaluated by measuring fruit yield and quality from the second harvest in response to different treatments of organic fertilizer. Seedlings were transplanted at New Mexico State University’s Fabian Garcia Science Center in Las Cruces, NM, on 2 June 2015. The experimental design was a Latin Square arranged in a 5 x 5 factorial treatment structure using twenty-five, 1.25 m² plots. Drip irrigation was installed so that plots in each treatment would receive the appropriate fertilizer treatment and equivalent irrigation. Each box contained eight plants of each cultivar. The treatments included: one time application of processed chicken manure (control), one time application of compost, multiple applications of compost tea, combination application of compost and compost tea (all with applications balanced to adjust for standard N application rate), and a onetime half application of processed chicken manure. Second green chile harvest occurred 116 days after transplanting. Within cultivars, no significant differences were observed in overall yield or fruit size. The organically sourced fertilizer treatments, including compost tea, produce green chile comparable in yield and fruit quality to the current standard treated chicken manure fertilizer regime. Interestingly, the half rate chicken manure treatment also provided comparable yield, indicating that organic producers may be able to reduce current application rates.

(091) Effects of Glucosinolates in Broccoli on Imported Cabbageworms and Implications for Organic Pest Management
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The imported cabbageworm (*Pieris rapae* L.) is a specialist herbivore that feeds on species in the Brassicaceae (mustard or cruciferous) family. It is a serious economic pest in commercial horticulture because larvae chew large holes in leaves, can destroy developing heads of broccoli, cauliflower, and cabbage, and otherwise contaminate or stain produce, rendering the produce unmarketable. In conventional systems, this pest is controlled with broad-spectrum insecticides, but *P. rapae* is notoriously difficult to manage in organic systems. While there is conflicting evidence on the effects of the naturally occurring defensive compounds (glucosinolates) found in brassicas on specialist herbivores such as *P. rapae*, understanding the roles that they play in mediating plant-insect interactions may provide alternative pest management strategies. Working on two certified organic sites in the upper Midwest (St. Paul, MN, and Ramsey, MN), as well as in the greenhouse, replicated experiments were conducted to determine 1) the glucosinolate content in six field grown broccoli (*Brassica oleracea* var. *italica*) varieties and correlate glucosinolate concentration to *P. rapae* egg and larval populations; 2) if previous herbivore damage influences broccoli defense against lepidopteran pests by inducing glucosinolates; and 3) if previous herbivore damage influences feeding by lepidopteran pests. Results show that broccoli varieties vary widely in glucosinolate content, and we will report these results. Implications of this research could lead to selection of cultivars with specific glucosinolate profiles to reduce pest pressure in organic systems.

Specified Source(s) of Funding: NCR-SARE

Poster Session—Ornamental Plant Breeding 2
(144) Cross Compatibility Studies in Lilac (*Syringa* L.)
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Lilacs represents a group of ornamental group trees and shrubs in Oleaceae consisting of 22 to 30 species from two distinct centers of diversity, the highlands of East Asia and the Balkan-Carpathian region of Europe. Current phylogenies recognizes five series within *Syringa*: *Pubescentes*, *Vilosae*, *Ligustrina*, *Pinnatifoliae*, and *Syringa*. Intraspecific and interspecific hybridization are proven methods for developing cultivars with improved flowering, new foliar phenotypes, and improved habits. However, interseries hybridization has proven more difficult with only successful hybrids produced from crosses between taxa in series *Syringa* with *S. pinnatifolia* in series *Pinnatifoliae*. Though hundreds of improved lilac cultivars have been introduced, fertility and cross compatibility among cultivars, species, and series have yet to be investigated in a formal study. Over three years, a cross compatibility study was performed on elite cultivars and species in series *Syringa*, *Pubescentes*, and *Vilosae*. Interseries, Interspecific, and intraspecific crosses were attempted resulting in a total of 27,749 pollinations with an aver-
were the species (the backcross hybrids were significantly more damaged than A multiple means comparison test using Tukey revealed that the most damage followed by the commercial hybrids. The damage (P < 0.0001), interspecific hybrids showing the most damage followed by the commercial hybrids. The interspecific hybrids and the species had little or no damage. A multiple means comparison test using Tukey revealed that the backcross hybrids were significantly more damaged than were the species (P < 0.05), interspecific hybrids (P < 0.0001), and commercial cultivars (P < 0.0001). The effect of pruning was significant (P = < 0.05); the pruned genotypes were less susceptible to spider mite damage. No interaction between genotype and pruning was found (P = 0.2328).

Specified Source(s) of Funding: University of Georgia Research Foundation

(146) Studies on Flower Color Inheritance and Relations Between Flower Color and Pigments in Cross-breeding Hybrids Between Iris dichotoma and Iris domestica

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Both Iris dichotoma and Iris domestica showed excellent resistance to cold, drought and barren stresses, and they can be unprotected for overwintering outdoor in Northern China. The objective of the study was to determine the inheritance pattern of flower pigment and anthocyanin components in hybrid seedlings. When Iris domestica was used as a female parent, all the three relative F₁ plants and F₂ hybrids showed a similar color to their female parent. When Iris dichotoma (purple, yellow, white) acted as a female parent, the flower color of three F₁ plants was purple, brown and violet, respectively, and the flowers of F₂ hybrids had large variations in colors. The colors of the petals were recorded by photographs and indicated by the code number of the Royal Horticultural Society Color Chart (RHSCC). The lightness (L*) of the petal color and two chromatic components a* and b* of the CIE L*a*b* color coordinate were measured by using a Color Reader (CR-400). The results showed that all individuals used in this study were categorized into 9 groups: purple, violet, red, pink, orange, brown, yellow, white, and composite color. Twenty-three kinds of anthocyanins were detected from the petals of the hybrid populations by using the high performance liquid chromatography-mass spectrometry (HPLC–MS). Different populations with different genetic background correlated with different types of anthocyanins and different flower colors. Therefore, the knowledge on how the content and type of anthocyanins determining the petal coloration of flowers will help provide information for a comprehensive understanding of the flower color characteristics in hybrid progenies, and it would be also useful for breeding new Iris cultivars with novel flower colors.

(145) Southern Red Mite in Abelia

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Approximately 400 different genotypes of Abelia (Caprifoliaceae) (species, interspecific hybrids, backcross hybrids and commercial cultivars) were screened for Southern Red mite (Oligonychus ilicis (McGregor)) damage in field plots on the University of Georgia Griffin Campus, Griffin, GA during the spring of the years 2011 and 2013. A visual rating scale of 0 to 3 was used to assess the damage, with 0 indicating no damage and 3 indicating severe damage. Southern red mite damage occurred in the spring on new growth. Severely affected plants were partially defoliated and new foliage was deformed. Leaf stippling was evident on all affected plants. Plants recovered by mid-summer and no damage was seen in the fall. Genotype had a highly significant effect on the level of spider mite damage (P < 0.0001), with the backcross hybrids showing the most damage followed by the commercial hybrids. The interspecific hybrids and the species had little or no damage. A multiple means comparison test using Tukey revealed that the backcross hybrids were significantly more damaged than were the species (P < 0.05), interspecific hybrids (P < 0.0001), and commercial cultivars (P < 0.0001). The effect of pruning was significant (P = < 0.05); the pruned genotypes were less susceptible to spider mite damage. No interaction between

An asterisk (*) following a name indicates the presenting author.
In some plants, polyploidy results in significant enlargement in cell size that in turn results in thicker, broader leaves, larger flowers with greater substance, rounder conformation and intensified coloration and larger fruits than their diploid counterparts. This poster illustrates these distinctive morphological comparisons for Albizia saman, Cassia bakeriana, C. fistula, C. javanica, Delonix regia, Dracaena fragrans, Marsdenia floribunda, Pachira aquatic, and Plumeria stenopetala.

(148) Preliminary Study on the Optimization of the Heavy-Ion Dose for Mutation Breeding in Three Lilium Species
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Heavy-ion beam technology is an excellent tool in mutation breeding of horticultural plants. This approach has been applied in more than twenty ornamental plants and many novel mutations and varieties have been thus obtained. In this study, dry seeds from three Lilium species (L. leichtlinii var. maximowiczii, L. cernuum, and L. amabile) were laid flat in dishes and irradiated with 12C+ heavy-ion at doses of 0 (control), 10, 20, 30, 40, 50, and 100 Gy in the Heavy Ion Research Facility in Lanzhou, China. The irradiated and control seeds were soaked in water for 24 hours, the wings of seeds were cut, and then placed on the germination medium. There were four responses in the growth of irradiated seeds: no germination, abnormal germination, normal germination but failure of roots/bulblet formation, and normal germination with successful formation of roots/bulblet. The germination rates of all irradiated seeds first rose but then fell because some irradiated seeds did not form roots. The survival rates increased according to the records after 90 days growth and intersected with germination rates as the levels of radiation decreased. Generally speaking, the germination rates and survival rates decreased with increased radiation dose in L. leichtlinii var. maximowiczii and L. amabile. However, a saddle-shaped curve was observed in L. cernuum. The species differed substantially in seed growth with the same radiation dose, which was likely caused by the differences in thickness of the testa. It is speculated that the appropriate doses for mutation breeding are 10–20 Gy for L. leichtlinii var. maximowiczii, 20 and 50 Gy for L. cernuum, and 40–50 Gy for L. amabile.

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(149) ‘Seasons in the Sun’, a Colorful New Little Bluestem for Landscapes
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Schizachyrium scoparium, little bluestem, is a warm-season perennial grass native to much of North America. This drought-tolerant plant is tough and adaptable. It is becoming more popular in landscaping due to its low maintenance and attractive foliage, as well as increasing interest in using native plants. A new cultivar of little bluestem, ‘Seasons in the Sun’, was developed from a project between the University of Georgia and USDA. Little bluestem accessions were evaluated in the field, and seeds from open pollination were collected. Selections were made from among the resulting seedlings, and following another round of pollination and seedling evaluation, a plant with colorful foliage was identified. This plant, coded as B20-10, was propagated via division, and planted in a replicated field plot in Griffin and Blairsville, Georgia (cold hardiness zones 8a and 6b, respectively). Selection B20-10 has soft arching foliage and upright flowering culms. Height after four seasons in the field ranged from 104 to 110 cm at full bloom. Foliage height was 41 to 52 cm and width was 35 to 53 cm. In the spring, foliage is yellow-green at the base, changing to red-purple from mid-way to the distal end of each leaf. Throughout the summer, foliage is a mix of green and grayed-purple. In the fall, the distal 80% of most leaves are purple or greyed-purple. Foliage was similar in color at both Griffin and Blairsville, indicating that color was expressed even with higher summer temperatures. ‘Seasons in the Sun’ is readily propagated via root division. It has been released as one of three cultivars in the ‘Hit Parade’ series.

Specified Source(s) of Funding: University of Georgia Research Foundation

(150) QTL Identification for Plant and Flower Traits Using Interspecific Recombinant Inbred Populations Derived from Petunia axillaris, P. exserta, and P. integrifolia
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Petunia is a popular bedding plant and a major commercial ornamental crop in the world. Identification of valuable alleles in wild species and introgression into elite germplasm are important for breaking current barriers in petunia breeding. In this study, two F₂ recombinant inbred populations derived from the crosses between Petunia xylarris x P. exserta (AE) and P. integrifolia x P. axillaris (IA) were phenotyped for days to anthesis (DTA), flower counts (FC), flower diameter (FD), flower development rate (FDR), flower length (FL), plant height (PH), plant spread (PS), and plant size (PZ) in central Florida in 2014 and 2015. Transgressive segregation was observed in both AE and IA F₂ populations for eight and five traits, respectively. The broad-sense heritability on a two-year basis for eight traits varied from 0.38 (FC) to 0.82 (FL) (IA F₂ population), and 0.21 (DTA) to 0.62 (FL) (AE F₂ population). Two single nucleotide polymorphism (SNP) bins maps that spanned 274.7 cM containing 343 bins (AE F₂ population) and 220.2 cM comprising 536 bins (IA F₂ population) were used to identify quantitative trait loci (QTL) for these traits. In the AE F₂ population, 22 QTL were identified and localized to linkage groups (LGs) 1, 2, 3, 4, and 7. Eleven of the QTL (50.0%) were consistent in both years, and some major QTL explained up to 26.8%, 25.3%, and 22.6% of the phenotypic variance for FDR, FD, and FC, respectively. In the IA population, we detected 26 QTL in LGs 1, 2, 3, 4, and 6; 12 (46.2%) of the QTL were consistently identified in both years, and some major QTL explained a total phenotypic variation up to 30.2%, 35.3%, and 47.1% for PS, FL, and FD, respectively. A number of the identified QTL were co-localized in several chromosomal intervals; these intervals could be very valuable for petunia breeding and introgressing desirable alleles into commercial petunia cultivars.

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(151) De Novo Assembly, Annotation, and Characterization of Root Transcriptomes of Caladium (Caladium xhortulanum)

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Caladium (Caladium xhortulanum Birdseye), a member of the Araceae (aroid) family, is an important foliage plant used in pots, hanging baskets and landscapes. The great majority of commercial caladium plants are forced from tubers. Pythium root rot is a major disease affecting caladium root health and tuber yield and quality. Improving caladium resistance to Pythium root rot has become an important objective in caladium breeding. Previous studies have shown the existence of moderate levels of difference among caladium cultivars in Pythium root rot resistance. The objective of this study was to sequence, assemble, annotate, and characterize the root transcriptomes of three caladium cultivars with different levels of Pythium root rot resistance, using the high throughput sequencing platform Illumina HiSeq2000. Forty-six to 61 million clean sequence reads were obtained for the root transcriptome of ‘Candidum’ (CDD; moderately resistant to Pythium root rot), ‘Gingerland’ (GGL; highly susceptible to Pythium root rot) and ‘Miss Muffet’ (MFT; highly susceptible to Pythium root rot). De novo assembly of these reads generated approximately 130,000 unigenes, with an N50 length of 1,755 bp. Based on sequence similarity search with known proteins, 71,825 (52.3%) genes were identified and annotated against the NCBI non-redundant protein and SwissProt databases. Out of these annotated unigenes, 48,417 (67.4%), and 31,417 (72.7%) were assigned to gene ontology (GO) and clusters of orthologous group (COG), respectively. In addition, 46,406 (64.6%) genes were assigned to 128 Kyoto Encyclopedia of Genes and Genomes (KEGG) pathways. Among the primary KEGG categories, metabolism was the largest category (12,474, 26.88%), indicating that active metabolic process in caladium roots. A total of 17,755 and 14,902 unigenes were differentially expressed (DE) between CCD and GGL, and CCD and MFT, respectively; 182 of these DE unigenes seemed to be involved in plant disease resistance or defense response processes. By using unigenes as reference, 28,837 simple sequence repeat (SSR) sites were identified, and the most dominant type was dinucleotide repeats (15,504; 53.8%). A search for single nucleotide polymorphisms (SNPs) identified 44,628 SNPs; the most abundant SNPs were transition-type (about 60.1%) of cytosine to thymine (C-T) or adenine to guanine (A-G). The information of assembled transcriptome, identified SSR and SNPs markers in this study could serve as an important foundation for further genomics studies in caladium as well as other species in the Araceae family.

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Poster Session—Photography

(062) Using 360 Degree Media and Spherical Projection Technologies to Create an Immersive Experience

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Cameras capable instantaneous 360° still and video images are becoming more readily available. Viewing these images is lagging behind the viewing technologies, but applications and headgear are now available to enable the use of this technology for use in instructional materials, extension materials and for research documentation. Some of these uses are reported own and demonstrated. Through the use of scripting, the images can be developed into interactive immersive field trips. Images are also useful for recording entire fields that can be explored.
Single photos taken instantaneously can capture a complete 360° image. Because the image is captured at one time there is no ghosting nor missing objects common when stitching multiple images. Sufficient light is necessary to prevent blurring due to a slow shutter speed. Some of the uses explored are how to incorporate these images into instructional materials that are accessed through Moodle. Online services that can store and share the images are compared. For viewing the images, Google Cardboard is an inexpensive approach that is very economical for individuals to experience an immersive viewing of images.

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**Poster Session—Postharvest 2**

(175) Stress Physiology of Postharvest Balsam Fir Trees As Influenced By Shaking and Baling

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It has been established that environmental conditions such as temperature and humidity have significant bearing on postharvest quality of Christmas trees. However, much is not known on stress physiology of Balsam fir Christmas trees subjected to various postharvest handling processes such as shaking and baling. It was, therefore, hypothesized that shaking and baling of balsam fir trees induce mechanical stress, causing membrane injury, stomatal closure, and increase in tree temperature under storage and transportation conditions leading to the trigger of ethylene and volatile terpene compounds (VTCs), promoting postharvest needle abscission. In all, 50, six-year-old trees, 90 cm in height with similar girth were used. Twenty-five trees were immediately subjected to shaking treatments of 0, 15, 30, and 60 seconds. Remaining 25 were baled at 0, 1, 2, 3, and 4 trees per bale. Tree core temperature was monitored using Thermal Infrared Imaging Technology, membrane injury of trees were studied by estimating membrane injury index (MII). Ethylene and VTC evolution were studied using designed airtight chamber for gas trapping, airtight syringe for ethylene and solid phase microextraction (SPME) kit for VTC extractions. Analysis of ethylene and VTC was accomplished using GC-FID. The study showed that shaking duration and tree baling have significant effect (P < 0.001) on tree core temperature. Shaking and baling of trees increased temperature by 2.3% and 3.5%, respectively, compared to control. Baled trees exhibited 35.1% higher MII compared to shaken trees, with MII ranging between 14.54 and 28.08%. The MII for shaken trees ranged between 14.5% and 20.7%, with 10 seconds shaken trees attaining the highest MII of 20.7%. The MII of shaken trees was 16.6% higher than the control. Shaking and baling of trees had a significant (P < 0.001) effect on ethylene evolution. 5-fold increase in ethylene evolution (4.66 µL·g⁻¹·h⁻¹) in baled trees compared to control (0.99 µL·g⁻¹·h⁻¹) was observed. A significant increase (68.1%) in VTC when trees were baled compared to control, on the other hand we observed 18% VTC increase in controlled treatment compared to shaken trees. This study suggests that postharvest handling of trees plays significant physiological alterations possibly contributing to postharvest needle loss.

Specified Source(s) of Funding: Atlantic Canada Opportunities Agency & The SMART Christmas Tree Research Cooperative

(176) Changes in Endogenous Hormone Levels Explains Seasonal Variation in Balsam Fir Postharvest Needle Abscission

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There are significant variations in postharvest characteristics of balsam fir trees, including the dynamics of abscission, water uptake, moisture content, and fluorescence. Changes in endogenous hormone levels in roots and needles are postulated to be related to these postharvest characteristics. Samples were obtained from 6 trees each month from April 2013 to November 2013 and evaluated for retention, chlorophyll fluorescence, water content, and water uptake. In addition, root and needle tissue were analyzed for abscisic acid, cytokinins, auxins, and gibberellins and their conjugates. Postharvest characteristics all improved in autumn as compared to spring, with a 3.5-fold increase in time to needle abscission commencement and 1.75-fold increase in time until complete abscission. There were several changes to root and needle hormones with respect to harvest time, but fewer hormones were linked to postharvest needle retention. Among all hormones analyzed, both isopentenyladenine and isopentenyladenosine in roots were strongly linked to needle retention. When isopentenyladenine was present in roots, needle abscission took 114% longer to begin and 58% longer to finish. Isopentenyladenosine in roots was the strongest hormonal predictor of needle retention (R² = 79%). Dihydrozeatin riboside (R² = 37%), trans-abscisic acid (R² = 50%), and isopentenyladenosine (R² = 59%) in the needles were also strong predictors of needle retention. The relative effectiveness of certain hormones in predicting needle retention and speculation pertaining to the roles these hormones could play are discussed.

Specified Source(s) of Funding: Atlantic Canada Opportunities Agency, SMART Christmas Tree Research Cooperative

(177) Evaluation of Volatile Compounds Responsible for the Aroma of Fresh Peaches

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An asterisk (*) following a name indicates the presenting author.
Consumers have correlated volatile active compounds identified in a peach fruit during maturation with perceived quality. Some of these compounds are synthesized as a result of under-ripe and over-ripening of fruit, while others produce as the fruit matures. These compounds interact positively with the perception of a mature fruit flavor. Multiple volatile compounds have been identified and aroma attributes are established. This study surveyed six late season melting peach varieties grown in Fort Valley, GA, to compare major volatiles compounds and their aroma attributes. Fruit were harvested and stored in a refrigerated room for 5–7 days at (5 ± 2°C), followed by 2–3 days at room temperature (21 ± 1°C). Volatiles were separated by solid-phase micro-extraction coupled with gas chromatography-mass spectrometry (SPME GC-MS) technique. Volatiles were extracted from the headspace using a PDMS/DVB coated SPME fiber. Compounds were then identified using the NIST MS library based upon retention times. Linear retention indices were used to determine concentrations of individual compounds with their peak area. Fresh peach samples resulted in the detection of 177 volatile compounds, with major compounds being alcohols, esters, hydrocarbons/alkanes, aldehydes, and lactones. Thirty compounds previously reported in fresh peaches and 28 volatiles with potential impact in peach aroma, based on their sensory characteristics, were identified. Of alcohols detected, major compounds included: hexenols, (3-Hexen-1-ol, 2-Hexen-1-ol, 2-Hexenal, and 1-Hexenol) associated with green, fresh aromas; and decanal and nonanol, associated with citrus, floral and citrus, orange, respectively. Ester compounds found for all cultivars included hexanol acetate, associated with sweet, fruit aromas and methyl octanoate. Additionally, hydrocarbons/alkanes included undecane and heptadecane, and an aldehyde, benzaldehyde, known for its cherry/almond sweet aroma, were found in all varieties. Lactones, the most well known compounds to represent peach aroma, were γ-undecalactone, δ-decalactone, and γ-dodecalactone in all varieties. Of the thirty known volatiles in fresh peaches, Red Sun’ had the highest number of volatile compounds (22), followed by ‘Cresthaven’ (21), ‘August Prince’ and ‘Early August Prince’ (19), ‘Early Big Red’ (18), and ‘Flameprince’ with 13. When reporting all volatiles, fewest volatile compounds were found in ‘Flameprince’, while a highest number were found in ‘Early August Prince’, a peach well known for its aromatic properties and intense flavor. Further analyses of aroma quality combined with sensory evaluation can give insight into the impact of major aromatic compounds and their influence on consumer perception of aroma and flavor quality in peach.

**Poster Presentations**

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In the U.S. Pacific Northwest and Chile, producing sweet cherries with 4–5 weeks postharvest storage/shipping life is desirable especially for ocean transport. With protracted shipping, flavor deterioration is a significant arrival issue. The flavor deterioration includes bland flavor and bitter taste that is often associated with internal browning (IB). ‘Skeena’ fruit harvested at commercial maturity from 9 orchards were hydrocooled and packed in a modified atmosphere packaging (MAP) liner and stored at 0°C for 5 weeks. Atmospheres in MAP were equilibrated at O₂ ≈ 9.5% and CO₂ ≈ 10.6%. Cherry fruit of the 9 lots retained varied degrees of sensory flavor and developed varied degrees of bitter taste and IB. It was found that soluble solids content (SSC), titratable acidity (TA), K, Ca and B were positively and negatively correlated with sensory flavor score and negatively with bitter taste and IB scores. Fruit respiration rate, N, P, Mg, S, and other micronutrients were not found to be associated with fruit flavor. The bland flavor might be a result of TA reduction and have little correlation with volatile compounds. IB was positively and negatively correlated with malondialdehyde (MDA) (a lipid peroxidation product) and total antioxidant capacity (determined by DPPH and FRAP), respectively. From one orchard, ‘Skeena’ fruit were harvested when average skin color as described by CTIFL color chips was 4.0, 5.5, or 6.5. Compared to early harvests, the late harvested fruit had lower titratable acidity (TA) and sensory flavor score, higher amounts of ethanol and MDA contents, higher bitter taste and IB scores after 5 weeks at 0°C. Fruit with varied SSC (17.8% to 21.5%) were obtained in the same trees by manipulating crop loads (fruit densities) of 2–3, 5–7, or > 10 fruit/spur generated on scaffolds 30 d after bloom. After 5 weeks at 0°C, fruit with higher SSC retained higher sensory flavor, lower bitter taste and IB scores. In conclusion, fruit quality, nutrition, and harvest maturity affect arrival flavor quality of sweet cherries for long-distance transport.

**Specified Source(s) of Funding:** the Oregon Sweet Cherry Commission

An asterisk (*) following a name indicates the presenting author.
(179) Peach Fruit Flesh Types Differ in Softening Rates in Cold Storage and Shelf Storage

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Peach cultivars with diverse flesh types are becoming more commonly available and provide opportunities for market expansion and enhanced customer appeal. Efficient harvesting, handling, and storage practices for different flesh types need to be developed. We conducted a two-year study to quantify storage performance of peaches with different flesh ripening characteristics. Samples of 20-30 commercially mature peaches of the cultivars ‘Bounty’ (yellow melting flesh), ‘Gloria’ (yellow partially stony-hard flesh), ‘White Lady’ (white melting flesh), ‘Klondike’ (white melting flesh), and ‘Scarlet Rose’ (white stony-hard flesh) were evaluated at time of harvest, after 14 days in conventional cold storage (0 °C, 95% relative humidity), and after removal from 14 days of cold storage and then three days on a shelf at room temperature. We evaluated multiple harvest dates for each cultivar. Fruit flesh firmness, mass, diameter, total soluble solids, and total titratable acidity were measured at each evaluation time. Small, but significant changes in flesh firmness occurred in storage for all cultivars. Softening rates in cold storage averaged 0.1–0.6 lb/day. Rehardening of fruits harvested after already soft occurred in ‘Bounty’, ‘Klondike’, and ‘Gloria’. Softening rates on the shelf were; ‘Bounty’ 4.3, ‘Gloria’ 2.3, ‘White Lady’ 2.9, ‘Klondike’ 3.5, and ‘Scarlet Rose’ 0.8 lb/day. ‘Scarlet Rose’ fruit retain firmness on the shelf dramatically longer than the other cultivars tested and present an opportunity for product differentiation to the consumer.

Specified Source(s) of Funding: New Jersey Peach Promotion Council; Rutgers/NJAES

(180) Watercore Incidence in ‘Red Delicious’ Apple in Relation to IAD Values: Effect of Harvest Date, and Harvista and Retain Applications

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‘Red Delicious’ is susceptible to watercore development during maturation and ripening on the tree. Maturation as indicated by IAD values, starch pattern indices and internal ethylene concentrations (IECs), and the incidence and severity of watercore at the time of harvest and during cold storage, have been studied in relation to harvest date and use of the pre-harvest plant growth regulators (PGRs) 1-methylecyclopropene (1-MCP; Harvista) and aminoethoxyvinylglycine (AVG; ReTain). Freshly harvested fruit were sorted into IAD values of 0.2–1.8 in 0.2 unit increments and then stored in air at 0.5 °C and 85% relative humidity for 7 months. PGR applications decreased watercore incidence and severity relative to untreated fruit, and showed good correlations with IECs up to week 10 of storage. IAD values, IECs and watercore severity were poorly related after 28 weeks of storage in non-treated and treated fruit. Fruit without PGR treatment harvested one week earlier had lower IECs than either treated or non-treated fruit harvested a week later, but with the same degree of watercore disappearance after 28 weeks of cold storage. The DA meter may be useful for predicting fruit maturity and possible watercore severity at the time of fruit harvest, but disorder disappearance in long-term cold storage was more influenced by the date of fruit harvest.

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(181) The Effects of Netting, Fruit Position, and Maturity on the Development of Soft Scald in Malus domestica ‘Honeycrisp’ During Storage

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The purpose of this study was to investigate the influence of fruit position, harvest sequence and light environment on the occurrence of soft scald during storage of Malus domestica ‘Honeycrisp’ apples. Three fruit positions within the tree were investigated: top (2.1 meters above ground), middle (1.5 meters) and bottom (1.2 meters); fruit was harvested three times in weekly intervals under netting (Extenday™, 20% reduction in radiation) and control (no netting). Samples were collected from an orchard in Gleed (Yakima County, Washington) in 2015. After harvest, fruit was analyzed using standard maturity indicators (soluble solids content, titratable acidity, firmness, and starch index). The remaining fruit was stored in a commercial cold room for three months at 0.5 °C and semi-weekly measurements of the DA-index and soft scald occurrence (absent/present) were performed. We utilized the DA meter to determine its utility on non-destructively tracking fruit in forced chilling conditions to determine its capacity to detect chilling stress before visual symptoms appear on the fruit surface. The first soft scald symptoms were observed two weeks after harvest.

An asterisk (*) following a name indicates the presenting author.
At the conclusion of the study, fruit with advanced maturity at harvest (third pick) showed higher incidence of soft scald (up to 79%) than samples from the first (0%) and second (4% to 8%) pick. Furthermore, fruit position within the tree influenced the onset and the severity of soft scald symptoms. For example, fruit from the third pick, showed a higher soft scald occurrence (79%) in fruit samples from the bottom than the fruit from the middle (54% to 58%) and top (33%) part of the canopy. There was no significant difference between the netting and control treatment. The DA-index did not correlate with the occurrence of chilling injury in this and other studies. The possibility to improve postharvest performance of ‘Honeycrisp’ apples based on orchard criteria will be discussed.

(182) Delays to Blueberry Cooling and Effects on Storage Quality Under Commercial Conditions

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Commercially grown blueberries are often harvested, partially cooled and held overnight for packing and final cooling the following day. However, consequences of this 24-hour delay on subsequent fruit quality have not been reported. Two tests were conducted in April and May 2015 on commercially harvested, southern highbush (Vaccinium corymbosum) blueberries (mixture of ‘Farthing’, ‘Sweetcrisp’, ‘Emerald’). Immediately after harvest six fruits were each fitted with a recording thermistor probe (2-mm diameter) and placed within the center of the fruit (± 3 kg) in each of six field lugs on the sixth layer from the base of a standard (100 cm x 120 cm) pallet. Probed fruit were positioned so as to measure pulp temperatures across the layer (air inlet, center, outlet) during partial forced-air (FA) cooling immediately after harvest. Half of these samples were packed into rigid, “clamshell” containers (312 g each; 8-carton), and FA cooled to final storage temperature. The other half were held overnight in the refrigerated packing area, and packed and FA cooled the following day. Following packing each probed fruit was repositioned in the center of a clamshell in the first three layers on the pallet to track pulp temperature during final forced-air cooling. Following final cooling, cartons were stored in the laboratory at 1°C/88% relative humidity and analyzed over 21 d. Partial FA cooling lowered mean fruit temperature to 18 °C within 90 min of harvest; fruit held overnight cooled further to 10.6 °C prior to packing. Total time through final FA cooling was 6.3 hours (day of harvest) and 26.5 hours (following day). 7/8 Cooling was achieved during both cooling events. Storage time had a greater effect on blueberry quality than did the 24-hour delay to packing and cooling. Weight loss roughly doubled each 7 d to 1.83% after 21 d. Although fruit appearance was acceptable after 14 d, incidence of shriveling increased from 7.0% to 46% after 14 and 21 d of storage, respectively. Fruit remained firm throughout storage (1.67 N mm); soluble solids content remained constant (10.2%), whereas total titratable acidity decreased by approximately 20% to 0.44% (citric acid basis). Decay was minimal after 21 days (4%). Based on these results, rapid cooling to 18 °C within 90 min of harvest permitted blueberries to be held overnight and packed the following day with minimal negative effects on quality during subsequent storage. Delays from harvest to initial cooling, though not tested here, may negatively affect quality during shipping.

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(183) Changes in Nutraceutical Compounds during Postharvest Storage of Blackberries

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Blackberries are excellent sources of nutraceutical-rich polyphenolic compounds such as anthocyanins and other antioxidants. This study investigated the changes in nutraceutical compounds of blackberries during postharvest storage. Eleven blackberry genotypes (‘Natchez’, ‘Osage’, ‘Ouachita’, ‘Prime-Ark® 45’, ‘Prime-Ark® Traveler’, A-2418, A-2434, A-2450, A-2453, A-2491, and APF-268) from the University of Arkansas blackberry breeding program were analyzed. Berries were harvested in June 2015 at the shiny-black stage of maturity and placed in 240-g vented clamshells in triplicate for each genotype. Nutraceutical compounds were measured before and after storage at 2 °C (90% RH) for 7 d. Total phenolics (mg gallic acid/100 g fresh weight (FW), total anthocyanins (mg cyanidin 3-glucoside/100 g FW), total flavonols (mg rutin/100 g FW), and total ellagitannins (mg ellagic acid/100 g FW) were evaluated. The level of polyphenolic compounds varied among the genotypes and increased after 7 d of storage. Before storage, the average across genotypes of total phenolics was 382.2 mg/100 g, anthocyanins 206.0 mg/100 g, flavonols 7.7 mg/100 g, and ellagitannins 27.1 mg/100 g. After storage, the average total

An asterisk (*) following a name indicates the presenting author.
phenolics increased 17%, anthocyanins 9%, flavonols 53%, and ellagitannins 13%. Selection A-2450 had the highest level of total phenolics and total anthocyanins, 502.7 mg/100 g and 271.8 mg/100 g, respectively, while ‘Prime-Ark® Traveler’ had the lowest levels (336.3 mg/100 g and 124.4 mg/100 g). ‘Prime Ark® 45’ had the highest level of flavonols (14.8 mg/100 g) and ‘Ouachita’ the lowest (6.3 mg/100 g). ‘Natchez’ had the highest level of ellagitannins (42.8 mg/100 g) and A-2453 the lowest (18.2 mg/100 g). Our data support the conclusion that these genotypes can be stored for 7 d without loss of nutraceutical compounds.

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(184) Elucidating Mechanisms of Postharvest Shelf-life in Blueberries

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Blueberry is a rapidly growing commodity in the United States with a production of ~261,374 metric tonnes in 2014. One of the reasons for this increased demand is consumer awareness about its potential health benefits. However blueberry is a highly perishable commodity and has a shelf life of 2–3 weeks. With increased production it becomes important to develop an understanding of mechanisms toward extending its shelf life. Currently the factors that determine shelf-life extension in blueberries are unknown. The objective of this study was to investigate the mechanisms that determine the postharvest shelf life in blueberries. Eight blueberry cultivars were evaluated for various postharvest attributes such as fruit weight, fruit texture, soluble solids and titratable acidity during storage. Of these, we identified two cultivars with higher firmness and longer shelf life and two other cultivars with poor fruit attributes during storage. These fruits are being evaluated for sugars, sugar-derivatives, organic acids, and flavonoids content using gas chromatography to identify metabolites that may be critical in extending shelf life and maintaining superior fruit quality attributes. In addition, transcriptome sequencing will identify key metabolic pathways that contribute to shelf-life extension in blueberries. Collectively, this study will improve the understanding of the relationships among changes in metabolite composition and key hormone-metabolism/regulatory pathways in blueberries, and can further extend the shelf-life in blueberry.

(227) Pre-grafting FoliarTrimming Intensity Effects on Healing and Regrowth of Newly Grafted Pepper Seedlings

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Wound healing is a complex process involving a cascade of coordinated reactions at the wound site and elsewhere. Callus formation is a common early step in restoring tissue structure and function. Newly grafted pepper seedlings tend to callus less and require more time to heal than tomato and other routinely-grafted crops, challenging propagators. Since low-intensity wounding can trigger whole-plant responses that may speed wound healing at grafting, we set out to determine if the timing and intensity of scion foliar trimming would influence the success or regrowth rate in newly grafted pepper plants. ‘Aristotle’ and ‘Scarface’ seedlings were grown from seed in a climate-controlled greenhouse at OARDC for thirty-three days. On Day 33 after seeding, non-destructive measures were taken on representative plants and a subset of plants was sacrificed to record plant biomass and other variables. Either 50% or 100% of the leaf area was removed from two other sets of identical plants on the same day with before and after measures confirming that treatment targets were met. The process was repeated on Day 35 after seeding, with untrimmed and trimmed (50% and 100% two and zero days before grafting) scions then splice-grafted to untrimmed rootstock seedlings. Grafted and ungrafted plant condition was monitored for fifteen days after grafting using a total of fourteen destructive and non-destructive measures. Graft success was unaffected by trimming, with success rates exceeding 90% in all treatments. However, levels of grafted plant growth (fresh and dry wt., leaf area) tended to be greatest when scion seedlings were not trimmed before grafting, although 50% trimming increased rootstock and scion stem diameter near the graft union. Timing showed significant differences in seven variables, whereas intensity presented significant differences in twelve variables. While trimming appears to slow grafting, it did not lower grafting success. If trimming is thought to confer advantages in large-scale grafting operations, follow-up research should focus on why it slowed regrowth in this study.

(228) Somatic Embryogenesis of the Rare Cultivars, Stewartia malacodendron ‘Delmarva’ and Stewartia ovata ‘Red Rose’

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Propagation of rare and endangered plant species via seed is often challenging due to difficulties with seed collection, low seed yields and viability, and sometimes complicated, requirements for germination. Also, sites for collection are few and the amounts of seed and plant material are limited. Other barriers to propagation of unique plant species include difficulty in rooting cuttings and successful acclimation. As an alternative to propagation by seed and/or cuttings, this research investigated the use of cuttings and successful acclimation. As an alternative to propagation via cuttings because of each tree’s recalcitrance to rooting. Not only are the mother trees unique in ornamental characteristics and few in number, the trees are very old, 40 + years, and declining in health. Seeds from immature fruit capsules of each cultivar were surface-disinfested and zygotic embryos were aseptically excised and cultured on sterile semisolid culture media supplemented with various types and concentrations of plant growth regulators. Somatic embryogenesis was induced from embryo explants of Symplocos paniculata \('Delmarva’\) and Stewartia ovate \('Red Rose.’\) The cultivars are difficult to propagate via cuttings because of each tree’s recalcitrance to rooting. Not only are the mother trees unique in ornamental characteristics and few in number, the trees are very old, 40 + years, and declining in health. Seeds from immature fruit capsules of each cultivar were surface-disinfested and zygotic embryos were aseptically excised and cultured on sterile semisolid culture media supplemented with various types and concentrations of plant growth regulators. Somatic embryogenesis was induced from embryo explants of Symplocos paniculata \('Delmarva’) and Stewartia ovate \('Red Rose’) at a very low frequency in the presence of 0.1 mg/L picloram. A few somatic embryos of Stewartia ovate \('Red Rose’) have converted to plantlets and will be transferred to soil shortly. Propagation of elite Stewartia cultivars demonstrates the ability to increase the populations of rare woody plant species with unique ornamental characteristics to support availability for the horticulture industry.

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(229) Symplocos paniculata, a New Ornamental Plant Species

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Symplocos paniculata is a widespread species in China with unique ornamental characteristics such as dark green leaves, fragrant creamy white flowers, sapphire-blue berries, and rough yellowish-brown and corky bark. It is easy to grow, tolerant to drought condition and high soil salinity and resistant to pests; thus it is considered a potential ornamental plant for urban landscapes. Attentions have been recently paid to the development and utilization of its fruit oil for biodiesel production; however, little research-based information is available on its potential on ornamental usage. This paper highlights the progress of the selection of novel cultivars and reviews the propagation techniques including seed propagation, cutting, grafting, and tissue culture. Such information plays a vital role in the development of this species for commercial production for green industry.

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(230) Micropropagation of Black Cohosh

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Black cohosh (Actaea racemose) is considered one of the top selling herbs in the United States. Its popularity is developing into a problem because it is normally a slow-growing perennial that takes up to 4–6 years to mature and provide plant parts for medicinal uses. The over collection of this species has caused habitat destruction for this species thus leading to becoming an endangered species. Production with true black cohosh seeds is unreliable because the seeds must be stratified and usually germinate over a period of two years after sowing. Therefore, this research was initiated to develop a micropropagation protocol with a goal of significantly increasing production of this highly demanded medicinal plant. Tender leaves of black cohosh plants grown in a campus greenhouse were used as explant materials. Following a standard surface disinfection procedure, the leaves were cut into one square centimeter pieces and cultured on Murashige and Skoog base medium supplemented with different plant growth regulators (TDZ, BA, kinetin, IBA, and NAA). The cultures were incubated in a plant growth chamber at 23 °C under 16 hours of light per day. After eight weeks of culturing, leaf explants from the BA, TDZ and kinetin treatments produced plantlet clusters. Those plantlet clusters were subsequently rooted in vitro in a medium containing IBA or NAA. Rooted plantlets were then acclimatized and are currently growing showing normal morphology as the stock plants from which they were cultivated in the same greenhouse.

An asterisk (*) following a name indicates the presenting author.
(231) Effects of Collection Date, Wounding, and Auxin Treatment on Rooting of Amelanchier spicata Propagated By Stem Cuttings

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Amelanchier spicata (dwarf serviceberry) is a shrub native to North America with ornamental and agricultural potential. Although other members of the genus may be propagated by stem cuttings, information on the propagation of this species is absent from the literature. Our objective was to evaluate the effects of collection date, wounding, and K-IBA treatment on adventitious rooting of softwood and semi-hardwood cuttings. Cuttings were collected from an indigenous population in Maine on 18 June, 1 July, 15 July, and 30 July, 2015. Half of the cuttings were wounded, and all were treated with a quick-dip of water or K-IBA at concentrations of 1000, 3000, and 5000 mg·L⁻¹. These treatments were selected because a preliminary experiment indicated that K-IBA was effective and concentrations above 5000 mg·L⁻¹ did not enhance rooting percentage or root quality. Following 61 days under intermittent mist, we recorded the percentage of cuttings producing roots and subjectively rated root systems based on overall quantity and quality of roots. Rooting percentages and root ratings diminished when annual growth transitioned to a semi-hardwood condition, and cuttings collected in late July did not produce roots consistently. Wounding significantly increased rooting percentage and root ratings among all cuttings treated with K-IBA. Among concentrations we evaluated, 5000 mg·L⁻¹ K-IBA promoted greatest root ratings for each collection time. Although rooting percentages were consistently high (80% to 100%) for wounded softwood cuttings, root ratings averaged only 2.1 out of five over the first three collection dates. Future work should investigate factors, such as juvenility and increased K-IBA concentration, which might increase the quality of adventitious root systems on stem cuttings of A. spicata.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture

(232) Jump Starting New Pawpaw Variety Production for the Industry: Developing Grafting and Top Working Approaches for Growers

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Pawpaw, a tree fruit native to the eastern United States, is in small-scale commercial production with its popularity on the rise. Pawpaw fruit have fresh market appeal for farmers' markets and Community Supported Agriculture (CSAs), and processing appeal for frozen pulp production for sale to gourmet restaurants. There are over 100 limited resource farmers in Kentucky alone who have small plantings of seedling pawpaw trees or wild trees that with grafting and top working could serve as rootstock and enable rapid production from grafts of high quality and high demand pawpaw fruit. The objective of this study was to develop methods to optimize grafting or budding success by cultivar and grafting time on pawpaw seedling rootstock trees. Six 17-year-old seedling trees were selected at the Kentucky State University (KSU) Harold R. Benson Research and Demonstration Farm, and branches were topworked with the pawpaw selections KSU Atwood, Hi1-4, Hi4-1, and Hi7-5 via bark inlay grafting in late May 2015. Additionally, thirty-five 4-year-old rootstock trees were topworked, by chip budding or whip and tongue, with the pawpaw selections KSU Atwood, Hi1-4, Hi4-1, and Hi7-5 on two dates, late-May and mid-June 2015. Chip budding was performed in May with dormant buds collected in March 2015. Whip and tongue grafts were performed in June with new green growth collected one day prior to grafting. None of the bark inlay grafts performed on older trees successfully formed graft unions. From this preliminary experiment, this method does not appear to be a feasible method for topworking pawpaw trees. Using earlier grafting dates and smaller branches may improve grafting success in the future. For chip budded trees, 44% of 4-year-old rootstock trees chip budded in May successfully formed graft unions. For the whip and tongue grafted trees, 41% of trees formed successful graft unions. Trees grafted with green wood showed more growth during the 2015 growing season. Trees chip budded with dormant wood healed; however, these buds showed little to no growth during the 2015 growing season. These grafts and buds will continue to be evaluated in 2016. Either of these grafting methods show promise for topworking smaller diameter pawpaw trees.

Specified Source(s) of Funding: SARE

(233) Tissue Culture Banana Program on Guam—Successes and Challenges

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Profitable production of bananas on Guam has been constrained by the limited availability of disease-free planting stock. The shortage of clean plant material can be overcome through in vitro propagation, which is efficient, fast and generates disease free plants. Guam’s Department of Agriculture in collaboration with the University of Guam launched a large-scale tissue culture propagation program concentrating their efforts on more than twenty banana varieties from the West and South Pacific regions. A year after the initiation of the program, the tissue culture laboratory produced thousands of banana plants that were distributed to local farmers and residents at a nominal cost.

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Local response was enthusiastic and over the next two years Department of Agriculture continued to supply plants that were far superior to plants available from other local sources. The need to carry on banana production in tissue culture become obvious and commercialization of seedling production became the next challenge. The Tissue Culture Laboratory is focusing its efforts on educating and training a local workforce that would likely find employment once private laboratories are created. Details pertaining to the establishment of this new program, its challenges and achievements will be presented and discussed.

Specified Source(s) of Funding: Speciality Crops Block Grant Program

(234) Establishing Sugarcane (Saccharum spp.) Genetic Resources In Vitro

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Sugarcane (Saccharum spp.) is used to produce sugar, a variety of alcoholic beverages, bagasse and industrial ethanol utilized in making fuel. In production fields, sugarcane is propagated vegetatively and currently, the crop’s genetic resources are also preserved as field plantings. The National Plant Germplasm System, USDA-ARS maintains 18 species of Saccharum with a total of over 2,400 accessions. To secure the collection from stress factors and invertible loss, efforts are made to introduce the germplasm into in vitro culture. Apical cane segments of S. officinarum, S. robustum and S. sinensis were sterilized in 70% isopropanol, subsequently in 2.5 % sodium hypochlorite and rinsed with sterile water. Excised shoots (ca. 10–15 mm long) were cultured on Murashige Skoog medium at 25 °C + 2 °C, at 16 hours photoperiod. Microbial contamination and phenolic compound secretion were the main visible factors preventing shoot development. After 3–4 weeks, contamination-free cultures developed an average of 2 shoots. In the next three subculture intervals (each lasting 4 weeks) and an addition of antioxidants to media (citric acid 100 mg·L⁻¹ or L-cysteine 100 mg·L⁻¹, or polyvinylpyrrolidone 300 mg·L⁻¹, or L-glutathione 50 mg·L⁻¹), the number of shoots increased from 2 to 8–12 shoots. In comparison to the control, some of the antioxidants tested showed a positive effect increasing the number of shoots and their vigor; however, the effectiveness was genotype specific. In our studies, only ca. 25% of explants produced clean and propagating cultures, and the in vitro establishing method requires further improvements. Introducing field-grown sugarcane plants in vitro is daunting; nevertheless, the effort is necessary to secure Saccharum genetic resources for food and industrial supply, research and distribution.

(235) Micropropagation of Fragrant Rhododendron fortunei Via In Vitro Shoot Culture

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Rhododendron fortunei Lindl. is native to China. Since its collection by Robert Fortune in the 19th century, this species has been increasingly produced for its showy and sweet-scent fragrant flowers and tolerance to low temperatures. It is propagated through seeds or stem cuttings. Seed propagation may produce plants that are not true-to-type, and cutting propagation has low survival rates. This study was carried out to develop a method for in vitro micropropagation of this species. Young stem cuttings of R. fortunei ssp. fortunei with two nodes were cultured on Anderson, Murishige and Skoog, McCown’s Woody Plant (WPM), and Economou and Read media supplemented with 4 mg/L zeatin with or without 1.0 mg/L NAA. Numbers of axillary shoots produced on WPM and Economou and Read media were similar but significantly higher than the other media. Economou and Read were subsequently used for improving shoot multiplication rates with zeatin at 0, 2, 4, and 8 mg/L in combination with 0 or 1.0 mg/L NAA. Up to 10 axillary shoots were produced per explant cultured on the medium containing 4.0 mg/L and 1.0 mg/L NAA. The shoots were rooted in half-strength Economou and Read medium supplemented with 0, 1, and 2 mg/L IBA. The rooting percentage was 100% in 60 days after shoots were cultured on the medium containing either 1.0 IBA or 2.0 mg/L IBA, and average root numbers were up to 10.83. Plantlets were transplanted into a soilless substrate and grown in a shaded greenhouse. Micropropagated plants were morphologically stable and grew vigorously with a 95% survival rate. This established method could be used for rapidly propagating disease-free liners and for speeding up new plant introduction and new cultivar release of R. fortunei.

(236) Date Palm Cultivar Identification through Simple Sequence Repeats (SSRs): A Practical Approach for Next-generation Commercial Date Palm Micropropagation Production

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Considerable effort is required to accurately identify specific cultivars of date palm (Phoenix dactylifera L.). Large-scale commercial facilities that practice clonal propagation of date
palm require a reliable method for quality control in its production during in vitro propagation, greenhouse growth and field nursery maintenance. The recent sequencing of the date palm genome has placed increasing pressure for absolute genotyping of date palm cultivars through the development of SNP microarrays. The use of a tailored simple sequence repeat (SSR) panel, using existing microsatellites in multiplex PCR, was used in date palm cultivar identification. A population of 56 of the most important date palm cultivars in the world was evaluated with sufficient genotypic polymorphism detected to distinguish 54 of the 56. The SSR panel of existing microsatellites could not confirm 18 of the 56 cultivars. This suggests that much greater intra-varietal diversity exists within the population. This in turn correlates with the fact that selection is much less stringent on male varieties, which have fewer identifiable morphological characteristics, whereas female varieties are traditionally and strictly propagated clonally in addition to being more easily identifiable by their fruit characteristics. The remaining 38 (33 females and 5 males) were evaluated in triplicate to confirm their successful fingerprinting. Further microsatellite markers will be required to fingerprint the remaining 18. These results demonstrate that routine date palm cultivar identification of in vitro plantlets, greenhouse grown and nursery plants are possible from the point of sale and beyond.

**Poster Session—Computer Applications in Horticulture**

**057 CPA Horoscope: The Future of Particle Analysis**

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For decades, particle analysis has been accomplished in horticultural science through the use of wire screenings to categorize particles according to screen sizes. Sieves, either round or square openings, determine particle size on the bases of minimum diameter and mass collected in each screen. Screens are usually stacked into a column and shaken or vibrated mechanically or manually for a determined period of time. This time usually varies according to the material. Particles that are not cubic or spherical in nature likely require more time to fall through the sieve column. Other particles may never reach the appropriate sieve screen due to their orientation on the screens. A computerized particle analyzer (CPA) (Tyler, Inc.) provides particle size and shape analysis that is unencumbered by the shortcomings of sieve analysis. Tyler’s CPA analyses each particle using a camera capable of detecting particles greater than 33 microns as the particle passes through a light source. Each particle is instantly analyzed according to the size definitions chosen (Equivalent diameter, minimum feret, maximum feret, length, skeletal length, or geodetic length) and cataloged in the program’s library. Each sample measured by the CPA is stored and can be reanalyzed, filtered for specific particles, or compared to other samples. The samples can be viewed and compared in similar fashions as sieve analysis. Through histograms or line graphs, samples are distributed according to their size class. Size classes can be standard 20 or 40 size increments or can be custom selected to view any specific range of size classes. The thorough analysis from the CPA includes distributions of a sample’s particle count, length, area, volume, or length to width ratio. Distributions of a sample’s means or percent of total with each size class can be used to further characterize a sample’s true particle distribution. Better understanding of particle shapes and characteristics can improve all facets of substrate research from the engineering of these materials to their use as container growing media. The extensive implications for this new analytical instrument are not just vital to furthering substrate research, but can be plentiful in many various agricultural disciplines.

**058 The Nuts and Bolts of Computerized Particle Analysis**

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A computerized particle analyzer (CPA) can be used in a variety of ways to determine counts and particle size measurements of a sample of many materials. The utility of this instrument to analyze an assortment of materials can directly correlate to its accuracy and precision. Accuracy and precision test were conducted on Tyler’s Computer Particle Analyzer 2. The CPA uses a conveyer system to throw objects between a 34 micron line scan camera and light source to determine particle parameters and analyze samples. Tall fescue seed samples of varying counts were used to determine the accuracy of the CPA. Counts of 100, 500, 1,000, and 5,000 were analyzed for total number of rejected particles (particles not fully captured) and touching particles. The mean accuracy for each sample size, 100, 500, 1,000, and 5,000, were 98%, 98.1%, 99%, and 98.5%, respectively. Precision of the CPA was tested using machined metal washers and nuts of known sizes. Overall, particles measured with the CPA varied ± 0.2 mm (5–6 pixels) from the actual particle sizes. This error could be attributed to the oscillation or twisting of the particle as it leaves the conveyor and crosses the scanning line. Objects with surfaces that are rounded and susceptible to roll could increase in the amount of error incurred during measurements. Given the minimal amount of error incurred in a sample’s count and particle dimension analysis, the computerized particle analyzer is one of the most accurate and precise instruments available for nondestructive particle analysis.
(059) CPA versus Rotap: Granulometric Analytical Comparison

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Tyler’s Computerized Particle Analyzer 2 (CPA) uses line scan imaging software to count and analyze particles of a given sample. Each image is grouped together and analyzed using software to separate the materials in personalized size classes. Similarly, traditional particle size distribution analysis using a Rotap separates a material by sieve sizes to yield a percent of the total mass captured in each sieve. In order to compare granulometric analysis from the two machines on a sample, five different horticultural sand sources were acquired for analysis. To accurately compare the CPA with the Rotap, the same 12 sieve sizes (or size classes) were used to analyze each sample. Using the size definition Minimum Feret and comparing the calculated volume percentage of each size class within each sample, the data obtained from the CPA (percentage of total volume per size class) were compared to the data obtained from the Rotap (percentage of total mass per sieve size) due to the consistency of sand particle density. Percent of sample lost in each method was also recorded. Using a volume model, the CPA was successfully able to identify similar trends in particle size distribution with half of the sample size necessary for the Rotap, 50 g as compared to 100 g. Sample loss during Rotap and CPA analysis ranged from 0.3% to 2% and 0.04% to 0.3%, respectively. Utilizing the CPA for granulometric analysis can effectively reduce sample loss and increase efficiency while providing many additional opportunities for analytical comparisons between samples.

(060) The Plant Elements of Design Plant Selection Program for Sustainable Landscaping

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Sustainable landscape design focuses on long-lived plants that thrive in their growing conditions. Too often, gardeners are wow’d by the visual aesthetics of a plant and neglect to take into account its optimal growing requirements—and whether the planting site meets those requirements. The Plant Elements of Design plant selection program supports the landscape design process by providing a tool for selecting plants based on matching their characteristics to the site. This program is useful as a reference for various audiences including horticulture students and educators, landscape designers and architects, Master Gardeners, home gardeners, nurseries and garden centers, and landscape contractors, managers, and maintenance firms. The program has 871 users (as of 19 Feb. 2016), and while intended primarily for plant selection, it may also be used, to a limited extent, for plant identification. This free, online database is populated with 2800 woody and herbaceous plants including 4500 downloadable images. Plants are chosen using 19 different plant characteristic and site categories such as plant type, size, soil type, light requirements, texture, seasonal interest, and landscape use. All perennial plants in the database are considered hardy in USDA zone 4 with adjoining zones indicated. Users can print plant data sheets including images, and select and export selected plants to a .csv file for use as a plant key, project management, and landscape planning. The Plant Elements of Design was developed over 15 years and is based on the knowledge and experience of University of Minnesota specialists, educators, and industry professionals.

(061) RSS Feed and News Aggregator Mobile Apps to Disseminate Information for Research, Extension, and Teaching

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Collaboration and cooperation within our college and between our college and the horticultural industry and public is important. This, in part, involves disseminating up-to-date information. The use of mobile devices and apps (applications), specifically RSS feed and news aggregator apps, can help achieve this. The objective was to develop an approach to help our college’s research, instruction, and extension personnel find and make current information to end users. Rich Site Summary or Really Simple Syndication (RSS) is a format for delivering changing web content to a user. The RSS feeds help you easily stay updated by retrieving the latest content from sites that you are interested in. New aggregators search the web to bring you news stories and information that is significant to you. Based on reviews of apps and my personal evaluation, I selected the iPad apps Feedly, Zite, Read by QxMD, Fox News, and those of local television news stations. These apps were used to retrieve pertinent articles, websites, news stories, and videos to colleagues in our department, college, and university, this was done by familiarizing myself with their research and extension projects, and what courses they teach. I e-mailed appropriate articles, websites, news stories, and videos to colleagues in our department, our college, graduate students, undergraduate students, student organizations such as the undergraduate Horticulture Society and the TPSS Graduate Student Organization; and the Coordinating Group on Alien Pest Species, Pacific Cooperative Studies Unit, University of Hawaii. I sent information to colleagues at the University of Hawaii at Hilo College of Agriculture, Forestry and Natural Resource Management, Windward Community College, and Leeward Community College. I further disseminated information to industry organizations such as the Hawaii Tropical Fruit Growers, Hawaii Export Nursery Association, Hawaii Department of Agriculture, Noela Elementary School teachers, and private companies such as Mari’s Gardens, Hawaiian Turfgrass,
and Island Fungi. Lastly, I shared information with colleagues in departments of horticulture at U.S. mainland universities. In conclusion, RSS Feed and News Aggregator apps have enabled me to disseminate relevant information to others and to demonstrate this approach for their possible adoption.

Specified Source(s) of Funding: Extension funds

**Poster Session—Environmental Stress Physiology**

(386) Using the Electrolyte Leakage Method to Determine Freeze Tolerance in Peach Fruitlets

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Late freezes cause fruit crop losses worth millions of dollars in the United States annually. In many fruit tree crops like peaches, a decrease of a few degrees can mean a complete loss of fruit, and although critical temperatures for the different development stages are well known, there are varietal differences in the temperatures that cause seed abortion and fruit loss. In this study, we set up a protocol to use the electrolyte leakage method for determining in-vitro lethal freezing temperatures of peach fruitlets. We tested three different protocols: 1) using fruitlet slices; 2) using fruitlets cut in half; and 3) using whole fruitlets. For each protocol, we used fruitlets from four different cultivars. Samples were placed in test tubes with deionized water, and immersed in a refrigerated water bath with decreasing temperatures between 0 °C and –10 °C at two-degree intervals. Every hour, we took out three replicate test tubes per cultivar and measured electrical conductivity (EC1). After introducing all the samples in an autoclaved at 121 °C for 20 minutes, electrical conductivity was measured again (EC2). Then, we estimated electrolyte leakage as EC1/EC2 (%) and plotted it against decreasing temperatures. Our results showed that the use of whole fruitlets can be successfully used for determining lethal freezing temperatures and for performing comparisons between different cultivars. However, the test tubes with fruitlet slices or fruitlets cut in half did not perform as well as the ones with the uncut fruitlets.

Specified Source(s) of Funding: South Carolina Peach Council

(387) Isolation and Characterization of an Ethylene Biosynthesis Gene in Response to Waterlogging in Chrysanthemum

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Waterlogging has major effects on natural vegetation and agricultural crops, resulting in retardation of growth and development of many plants mainly in humid regions. The phytohormone ethylene is known to mediate a diverse array of signaling processes during abiotic stress in plants. To better understand the roles of ethylene in response to waterlogging, a full-length CgACO cDNA (GenBank accession KT438660) was isolated from chrysanthemum and its expression patterns were examined in two Chrysanthemum species (Chrysanthemum zawadskii and C. nankingense) with differ tolerance to waterlogging. In the sensitive one (C. nankingense), the transcriptional levels of the CgACO were increased rapidly but only transiently (12 hours after treatment) in the roots. In tolerant one (C. zawadskii), the expression of the CgACO was increased rapidly and maintained up to 48 hours post-treatment. CgACO expression was not induced by exogenous ethylene application in both species. The ethylene inhibitor, 1-methylcyclopropene (1-MCP), enhanced CgACO expression after 12 hours of waterlogging in tolerant one but much less in the sensitive species. Higher expression of the CgACO gene correlated with higher accumulation of ethylene in the tolerant C. zawadskii. This supports the previously observed phenomenon that C. zawadskii exhibits well-developed aerenchyma adaptations to cope with waterlogged conditions.

(388) Transcriptome Analysis of Differentially Expressed Genes upon Treatment with Hydrogen Cyanamide in Peach

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Peaches are of considerable interest as an alternative crop for those hard hit in the Florida citrus industry, yet their temperate origins have challenged their production in a subtropical climate. Apart from various pests and diseases that reduce tree longevity and fruit quality, accumulating inadequate chill units for uniform bloom is a major challenge. Most of Florida’s chill hours are accumulated in December and January, but in recent years accumulated chilling units continue to decline. Hydrogen cyanamide (HC) is widely used around the globe where mild winters prevail and where there are insufficient accumulated chill units. Timely application of HC can enhance uniform bloom and leaf emergence, increasing labor efficiencies; however many growers have induced significant crop injury because the timing for different fruit crops is not well defined. The molecular mechanism of how HC works is still poorly understood and
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in order to find transcriptional pathways associated between dormancy release and HC application in peaches we analyzed the vegetative and reproductive buds of peach. The objective of this study is to identify gene expression triggered by HC application. ‘TropicBeauty’, a low-chill peach cultivar was sprayed with 1% hydrogen cyanamide (BudPro, Green Trees & Plants II, LLC, Marietta, GA) when pollen grains translucent. Single tree replicates were sprayed with HC and compared with control plants that were unsprayed controls. Vegetative and floral buds were collected from 4 branches per tree before application and then 1, 3, and 7 days after application. RNA isolation was performed to carry out cDNA synthesis for real-time PCR (RT-PCR). Ten genes involving dormancy release, cold regulation genes, and abscisic acid related genes were targeted for gene expression studies. These genes may play a role in dormancy release of buds due as a result of the hydrogen cyanamide treatment based on our observation that treated plants had both early uniform bloom and vegetative budburst approximately 30 days after HC application, whereas control trees that got inadequate chilling had a prolonged bloom, uneven leaf emergence and fruit ripening.

(389) Physical and Chemical Changes in Silty-Clay Soils in Response to Humic Acid and Sulfuric Acid, and Its Effects on Avocado Plant Water Status

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In response to low soil oxygenation, avocado plants reduce stomatal conductance, CO₂ assimilation and consequently plant biomass. In avocado orchards low soil oxygenation can affect fruit production and tree survival. Today in Chile some avocado orchards established in clay soils are managed including the application of high charges of sulfuric acid to the soil, as a tool for increasing soil macroporosity. However, the effect of this management has not been evaluated regarding to plant physiology and environment. On the other hand, there are organic products offered as alternatives to improve soil physical and chemical features. The objective of this study was to test the effects of sulfuric acid application to a silty-clay soil, and to compare soil and plant responses respect to control and humic acid application. The experiment was conducted during 11 months with 2-year-old ‘Hass’ avocado trees, grafted on clonal ‘Duke 7’ rootstock. The plants were established in 20-L pots containing silty-clay soil. In the experiment, trees were subjected to 4 treatments, T0: only water; T1: H₂SO₄ (0.3 cc/plant once a month); T2: humic acid (9 cc/plant every 15 days); T3: H₂SO₄ + humic acid. Some of the variables measured were: soil electrical conductivity (EC), soil pH, soil bulk density, soil Oxygen diffusion rate (ODR), soil saturated hydraulic conductivity (Ks), stem water potential (SWP) and leaf stomatal conductance (gs). The main results of this experiment showed that there was a significant effect of T1 on soil pH compared to control (T0) and humic acid (T2) applications. T2 had a significant effect in increasing soil ODR compared with T0 at one evaluation date. Soil EC was significantly higher in T3 at the end of the experiment. The T1 had Ks differences within the pot, with very low Ks in the soil located at the upper portion of the pot, but a very high Ks at the bottom of the pot. Respect to plant water status, avocado trees didn’t show differences in gs, but T1 showed a better SWP in one of the evaluation dates. Soil bulk density and others variables did not show differences during the evaluation period. As conclusion the evaluated treatments showed different but temporal effects in some soil physical features and soil pH, however it was not possible to see an effect in plant water status, indicating that probably longer time studies are needed to elucidate risks and advantages of each soil treatment on avocado plant physiology.

(390) The Interactive Effect of Elevated Carbon Dioxide, Temperature, and Water Deficit Stress on Growth and Flower Development of Petunia (Petunia xhybrida)

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Changes in climate, including increases in atmospheric CO₂, temperature, and water deficit, present a challenge to agriculture. In order to cope with environmental stress plants utilize morphological and physiological mechanisms to survive and mitigate the stress. These three environmental factors, among other factors,
play significant roles in plant growth and development. The goal of this research was to investigate plants’ morphological/physiological responses to the interaction of three abiotic environmental factors. Petunias were grown in growth chambers at two levels of CO₂ (400 and 800 µmol·mol⁻¹), two temperature regimes (21/18 and 28/25 °C day/night), and two water regimes (0.15 and 0.30 m³/m²) maintained by an automated irrigation system. To investigate the impact of simulated climate change, growth index, gas exchange, time to first fully open bloom, flower size, flower longevity and the number of flowers were measured. Preliminary results revealed that elevated CO₂ accelerated flowering time, mitigated the inhibitory effect of high temperature on flowering, and elevated temperature decreased the number of flowers per plant.

Specified Source(s) of Funding: West Virginia Agricultural and Forestry Experiment Station, Morgantown WV (HATCH Grant WVA00640)

(391) The Effect of Exogenous Calcium and Osmotic Stress on Temporary Water Stress Tolerance in Bedding Plant Seedlings

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Seedlings of bedding plants are often exposed to elevated temperature and/or water deficit stress during transportation. Such poor environmental conditions can decrease crop quality and cause crop loss. To mitigate damage from water stress, plants need to reduce transpirational water loss by closing their stomata. Osmotic stress induces stomatal closure similar to water deficit stress in plants and thus could be used to enhance water stress tolerance. Both water stress and osmotic stress trigger abscisic acid-signaling pathway, which increases the level of cytosolic calcium in guard cells. Calcium has been known to play an important role during the process of stomatal closure. The objective of our research was to investigate whether osmotic stress and/or exogenous calcium application delayed plant wilting and enhanced water stress tolerance in bedding plant plugs. Seedlings of Impatiens walleriana ‘Xtreme White’, Viola cornuta ‘Sorbet Midnight Glow’ and ‘Sorbet XP Yellow’, and Viola xwittrockiana ‘Matrix Blue Frost’ were used in this experiment. Osmotic stress inducing chemicals for treatments included CaCl₂, Ca(NO₃)₂ (calcium), and BaCl₂ and Ba(NO₃)₂ (non-calcium), and they were applied at 50, 100, and 150 mM. As an osmotic stress inducing control, mannitol was drenched on seedlings at 150 and 300 mM. All treatments delayed wilting and extended shelf life up to one day compared to non-treated control in two cultivars of V. cornuta, V. xwittrockiana (except at 50 mM) and I. walleriana (except at 150 mM). V. xwittrockiana treated at 50 mM did not show shelf life extension, while all treatments at 150 mM in I. walleriana caused leaf curling and accelerated wilting within six hours after application. No damage was observed in all treatments in violas and pansy. Mannitol application also increased shelf life in all cultivars tested. Our data indicated that treatments inducing osmotic stress seemed to be effective to delay wilting in seedlings of I. walleriana, V. cornuta, and V. xwittrockiana. To determine whether exogenous calcium application enhanced water stress tolerance, plants were pretreated with aforementioned chemicals 1, 2, and 4 days before water was withheld. The effect of pretreatment of each chemical on enhancing water deficit tolerance is currently being investigated.

(392) Morphological and Physiological Evaluations of Grafted Tomato Plants in Response to Salinity Stress

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Salinity is one of the most limiting factors that adversely affects growth and yield of vegetable crops. The capacity of plants to tolerate high levels of salinity depends on the ability to exclude salt from the root or sequester salt in vacuoles to tolerate high concentrations of salt in cytoplasm. The salt tolerance of vegetable crops is highly desirable as many high value vegetable crops including tomato are particularly susceptible to salinity stress. Grafting has been demonstrated as a useful, promising approach to cope with abiotic and biotic stresses in tomato. The objective of this study was to enhance the salinity tolerance of susceptible tomato genotype by grafting onto a salt-resistant rootstock. Three-week old tomato seedlings of two tomato genotypes, LA (salt-tolerant) and CA (salt-sensitive), were subjected to grafting treatments, i.e., non-graft and self-graft controls and reciprocal-graft. Plants were grown in a 1:1 (v/v) perlite and vermiculite mixture and received a modified Hoagland’s nutrient solution containing either 0 or 100 mM NaCl. Salinity reduced morphological parameters of tomato plants in all the treatments, including plant height, the number of leaves, leaf area, leaf length, days to flowering, biomass and root characteristics. However, these reductions were less prominent in tomato plant grafted onto a LA rootstock. Likewise, the Fv/Fm values of young fully expanded leaves were maintained higher when grafted onto a LA rootstock compared to other grafting treatments, where gradual reductions of the values were observed. It is concluded that adverse effects of salinity on tomato plants can be alleviated by grafting a sensitive tomato genotype onto a resistant rootstock.

(393) Effects of a Nonionic Surfactant on Growth, Physiology, and Drought Tolerance of Coleus (Solenostemon scutellarioides L. Codd)

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Plant growth and subsequent crop harvest is contingent upon sufficient water inputs. Many regions of the world experience persistent or temporal droughts. With a steadily increasing world population, already limited water resources will be spread even thinner, further increasing the pressure to use water more efficiently, especially in plant production. To further investigate the enhancement of water use efficiency in plant production we tested the nonionic surfactant Tween® 20 as an irrigation additive for its potential effects on growth, physiology, and drought tolerance of coleus. Four irrigation treatments were imposed upon coleus plants consisting of: 1) water only (control); 2) 100 ppm Tween® 20; 3) 320 ppm Hydretain®; and 4) 100 ppm AquaGro 2000 L. The products Hydretain® and AquaGro are somewhat similar in function to Tween® 20 and are currently used in industry practice which is why they were chosen for comparison. Experiments were conducted in a greenhouse and each of the treatment products were injected into irrigation water using a fertigation system. After one week of growth and data collection, coleus plants were given one final irrigation and then allowed to dry out, simulating drought conditions. After drought induction, we made daily observations on physiological parameters including transpiration, net photosynthesis, stomatal conductance. In preliminary studies, the use of Tween® 20 as an irrigation additive has shown potential to increase water use efficiency in plants by up to 40%.

(394) Relative Salt Tolerance of Twenty-Four Chili Pepper Cultivars
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A greenhouse experiment was conducted to screen 24 chili pepper cultivars (23 Capsicum annuum cultivars and one Capsicum frutescens cultivar) for salt tolerance. Seedlings were grown in 4-inch pots containing Metro-mix 360 commercial substrates. During the one-month experimental period (28 June to 29 July 2013), seedlings were treated with nutrient solution at electrical conductivity (EC) of 1.1 dS·m⁻¹ (control) or saline solution at EC of 5.0 dS·m⁻¹ (salt treatment) for a total of seven times. No visible foliar salt damage (leaf edge burn, necrosis, or discoloration) was observed on any chili pepper plants. However, salt treatment significantly reduced plant growth with large variations among cultivars. Plant height, leaf area, and shoot dry weight of 24 chili pepper cultivars decreased by 17% to 40%, 20% to 58%, and 23% to 51%, respectively. Cluster analysis was conducted using multivariate parameters including relative plant height, leaf area, and shoot dry weight. All chili pepper cultivars were classified into three groups. Capsicum annuum ‘El Rey Jalapeño’, ‘Guajillo’, ‘NuMex Big Jim’, ‘NuMex Conquistador’, and Capsicum frutescens ‘Greenleaf Tabasco’ were the most salt tolerant. Capsicum annuum ‘Carolina Cayenne’, ‘Cayenne Thick’, ‘El Jefe Jalapeño’, ‘NMCA 10652’, ‘NuMex Eclipse’, ‘NuMex R. Naky’, ‘NuMex Sunglo’, ‘Santa Fe Grande’, ‘Santaka’, and ‘Tam Veracruz’ had intermediate salt tolerance, whereas Capsicum annuum ‘Ancho’, ‘Ancho Mulato’, ‘Arizona’, ‘De Árbol’, ‘Early Jalapeño’, ‘NuMex Joe E. Parker’, ‘NuMex Sunburst’, ‘NuMex Sunflare’, and ‘Sweet Banana’ were salt sensitive.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture Hatch project TEX090450

(395) Evaluation of Salt Tolerance in Cultivated Potatoes (Solanum tuberosum L.) Based on Plant Growth and Tuber Yield
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Salinization of soil and water under global warming is one of the main yield-limiting factors in potato production. To determine salt tolerance of cultivated potatoes is very useful for sustainable potato cultivation and production yield stability. Eighteen potato cultivars were grown under the soil and irrigation water of three salinity conditions (EC 1.0 dS·m⁻¹ as control, 4 dS·m⁻¹, and 8 dS·m⁻¹). Relative aerial part weight (RAW; % control) and relative tuber yield (RTY; % control) were decreased in most cultivars according to salinity levels. Furthermore, the
responses of RAW and RTY to salt stress were very different among cultivars. Although some cultivars (‘Daejima’, ‘Goun’, ‘Haryeong’, and ‘LT-8’) showed higher RAW than other cultivars under salinity condition, RTY of them was lower and moreover in the case of ‘LT-8’ there was no tuberization. On the other hand, ‘Superior’, ‘Kroda’, ‘Romana’, and ‘Duback’ showed higher RTY despite of their lower RAW. Negative correlation was observed between RAW and RTY, especially in the case of over 80% RAW at EC 8 dS·m⁻¹. Increasing rate of proline content (IPC) was higher in the cultivars with high RAW than in the ones of high RTY. IPC showed a positive correlation with RAW at EC 8 dS·m⁻¹, while a negative correlation with RTY. Hence, this study suggests that potato cultivar with high aerial part growth and high proline content under salt stress does not necessarily mean the high yielding cultivar to salt stress. In terms of yield stability, ‘Superior’, ‘Kroda’, ‘Romana’, and ‘Duback’ could be more useful as salt tolerant cultivars than the ones such as ‘Daejima’ or ‘LT-8’.

**Poster Session—Floriculture 1**

**(282) Combining Close Spacing and Pinching to Increase Yields of Lisianthus Cut Flower Stems**

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Lisianthus (*Eustoma grandiflorum*) has become popular as a cut flower because of its long vase life and attractive, rose-like appearance. Productivity has been enhanced by closer plant spacing and by extending the harvest season in a high tunnel, but increasing the number of flowering stems per plant by pinching out the main stem growing point has not been widely practiced. In the present experiments, we compared the use of pinching at two plant populations (1.8 and 4 plants per ft²), with two cultivars (ABC 1-3 White in 2014 and Mariachi Grande 3 White in 2015, and ABC 1-3 Purple in both growing seasons). In both years, the experiments were duplicated in a high tunnel and an adjacent field. Yield of cut stems per unit area were increased 39% by pinching, and 14% by growth in the high tunnel. Increasing the plant population boosted yield by 51%, and the combination of close spacing and pinching doubled stem yield from 6.8 to 13.7 per ft². Stem length was increased 17 percent by growing the plants in the high tunnel, but not affected by the other treatments. Removal of the plants’ growing point in the vegetative stage (pinching) delayed the onset of flowering by a week, but did not affect the end of the flower production period. The cultivars tested reacted similarly to the treatments imposed, although they differed in earliness of flowering. Overall, stem yields were 66% higher in 2014 than in 2015, due in part to a harvest season three weeks longer, but those stems were 28% shorter. The combination of close spacing and pinching increased stem numbers but reduced the no. of flowers and flower buds per stem to a degree that might be detrimental to marketability.

**(283) Analysis of Floral Scent in Cymbidium ‘Sunny Bell’ By Electronic Nose and Gas Chromatography-mass Spectrometry**

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*Cymbidium* is the most important crop in the Orchidaceae family. There are several beautiful and colorful *Cymbidium* species flowers. Among them a few species of *Cymbidium* have a floral scent and flavor. Headspace-solid phase microextraction-gas chromatography-mass spectrometry (HS-SPME-GC-MS) was used to identify the floral scent of the different floral organs of *Cymbidium* cultivar ‘Sunny Bell’ for the evaluation of floral volatile polymorphism as a basis to determine the best time of harvest. Electronic nose analysis results, coupled with discriminant factor analysis, suggested that emitted odors varied in different *Cymbidium* cultivar ‘Sunny Bell’ floral organs, including the column, labellum, sepals, and petals. The first two discriminant factors explained 99.193% of total system variance. The major floral scent were α-pinene, octamethylcycloptetrasiloxane, β-myrcene, 2,6-dimethlnonane, eucalyptol, trans-β-ocimene, 4,8-dimethyl-1,3,7-nonatriene, linalool, and decamethylcyclopentasiloxane. Moreover, in a principal component analysis, sepals and petals were located closely on the score plot.

**(284) Study of Volatiles from the Flower of Bouvardia longiflora Using Electronic Nose and HS-SPME-GC-MS**

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Helleborus is commonly known as ‘Christmas Rose’, ‘Winter Rose’ and ‘Lenten Rose’. ISSR markers are highly polymorphic and are useful in studies on genetic diversity, phylogeny, gene tagging, genome mapping and evolutionary biology. We conducted a characteristic investigation and inter simple sequence repeat analysis for use as breeding parents through the classification of 17 Helleborus germplasm. In the present study, we used 100 ISSR primers for genetic diversity analysis of Helleborus, and 16 produced highly polymorphic DNA fragments. As per results, sixteen primers [(AG)\textsubscript{8}T, (GA)\textsubscript{8}T, (GA)\textsubscript{8}C, (CT)\textsubscript{8}A, (CT)\textsubscript{8}G, (GA)\textsubscript{8}YT, (GA)\textsubscript{8}YC, (CT)\textsubscript{8}RC, (CA)\textsubscript{8}RT, (GT)\textsubscript{8}YC, (TC)\textsubscript{8}RA, (TC)\textsubscript{8}RT, (AC)\textsubscript{8}YG, (TG)\textsubscript{8}RT, (CTTCA)\textsubscript{3} and (GGAGA)\textsubscript{3}] generated 100% polymorphic patterns in tested 17 Helleborus germplasm. Nei’s genetic diversity and Shannon’s information index had their highest value in primer (CA)\textsubscript{8}RT as 0.400 and 0.581, respectively, and the lowest value in primer (CTTCA)\textsubscript{3}, as 0.199 and 0.377, respectively. Based on acquired genotypes of 16 ISSR primers, we analyzed the genetic relationship of 17 Helleborus germplasm, and the tested germplasm was classified into three groups at genetic distance value of 0.22.

Based on these we results suggested that valid guidelines for the collection and conservation of Helleborus genetic resources.

(285) **Inter Simple Sequence Repeat Data Reveals the Physical Characteristics of Helleborus**

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**Helleborus** is an evergreen plant belongs to Ranunculaceae, it is commonly known as ‘Christmas Rose’, ‘Winter Rose’, and ‘Lenten Rose’. ISSR markers are highly polymorphic and are useful in studies on genetic diversity, phylogeny, gene tagging, genome mapping and evolutionary biology. We conducted a characteristic investigation and inter simple sequence repeat analysis for use as breeding parents through the classification of 17 Helleborus germplasm. In the present study, we used 100 ISSR primers for genetic diversity analysis of Helleborus, and 16 produced highly polymorphic DNA fragments. As per results, sixteen primers [(AG)\textsubscript{8}T, (GA)\textsubscript{8}T, (GA)\textsubscript{8}C, (CT)\textsubscript{8}A, (CT)\textsubscript{8}G, (GA)\textsubscript{8}YT, (GA)\textsubscript{8}YC, (CT)\textsubscript{8}RC, (CA)\textsubscript{8}RT, (GT)\textsubscript{8}YC, (TC)\textsubscript{8}RA, (TC)\textsubscript{8}RT, (AC)\textsubscript{8}YG, (TG)\textsubscript{8}RT, (CTTCA)\textsubscript{3} and (GGAGA)\textsubscript{3}] generated 100% polymorphic patterns in tested 17 Helleborus germplasm. Nei’s genetic diversity and Shannon’s information index had their highest value in primer (CA)\textsubscript{8}RT as 0.400 and 0.581, respectively, and the lowest value in primer (CTTCA)\textsubscript{3}, as 0.199 and 0.377, respectively. Based on acquired genotypes of 16 ISSR primers, we analyzed the genetic relationship of 17 Helleborus germplasm, and the tested germplasm was classified into three groups at genetic distance value of 0.22.

Based on these we results suggested that valid guidelines for the collection and conservation of Helleborus genetic resources.

(286) **Identification of Single Nucleotide Polymorphism (SNP) Markers Associated with Botrytis Resistance in Lily (Lilium spp.)**

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The genus *Lilium* belongs to the *Liliaceae* family, which is economically important ornamental monocot flowering plant and highly susceptible to *Botrytis* infection. A bulk segregant analysis was conducted in susceptible or resistant pools constructed from a parental cross between Asiatic, Oriental and Trumpet lilies to identify genes associated with resistance to Botrytis. Based on previously obtained transcriptome data, 16 cDNA libraries produced from 8 hybridizations for the bulk segregant analysis were then analyzed using differential gene expression (DEG) profiling. Potential up-regulated candidate transcripts—suspected to be linked with disease resistance—were identified during a DGE comparison between resistant and susceptible lines. A randomly chosen three candidate genes was evaluated by quantitative real-time PCR (qRT-PCR) to validate the DGE data. As the most common variation, allele specific single nucleotide polymorphisms (SNPs) in the candidate transcripts from the 16 progenies were analyzed and subsequently used to develop

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

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plants grown in the injection-molded biocontainers were of equal

combination of these fillers. In our 10-week greenhouse trials
dry grains with solubles (DDGS), lignin, BioRes, or selected

base resins of polylactic acid (PLA) or polyhydroxyalkanoate

dia.) that were injection molded on standard manufacturing

equipment, and compared their performance and compostability

of soil after use, but little information is available on the

niques linked with Botrytis resistance were identified. Further,
two EST-SNP markers (mRNA_310345 and mRNA_296428)

were tested on DNA sample panels of 16 lily lines to characterize

their functional PCR amplification and polymorphisms using

high resolution melting (HRM) analysis. It was found that both

EST-SNP markers have generated 10 unique HRM profiles and

showed a clear classification of 6–7 different lily genotypes in

almost according to their EST sequence characteristics

indicating that HRM is an efficient tool for the rapid screening

of sequence variations and allele discrimination. These result

findings highlights the significance of SNP genotyping by HMR
to identify the disease resistance genes in lily. With further

validation, the allele specific EST–SNP markers which were

identified in this study could be used for improving resistance
to Botrytis in lily breeding programs.

Specified Source(s) of Funding: This research was supported by

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(287) Performance and Compostability of

Improved Horticulture Containers Made of

Bioplastics and Biocomposites

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Horticulture containers made of bioplastics and biocomposites
can perform as well as petroleum-plastic containers during crop

production, and a few of these novel biocontainers can decom-
pose in soil after use, but little information is available on the

compostability of these containers in home composting systems.

In 2015, we evaluated the performance and compostability of

seven improved commercial-grade biocontainers (11.4-cm top
dia.) that were injection molded on standard manufacturing
equipment, and compared their performance and compostability

with those of a biopolymer-coated paper-fiber container and a

petroleum-plastic control container of the same size. Material

formulations for injection-molded biocontainers were made with

base resins of polylactic acid (PLA) or polyhydroxyalkanoate

(PHA) and were combined with fillers of soy protein, distillers
dry grains with solubles (DDGS), lignin, BioRes, or selected

combinations of these fillers. In our 10-week greenhouse trials

with Gerbera daisy (Gerbera jamesonii Bolus ex. Hook f.),
plants grown in the injection-molded biocontainers were of equal

quality to those grown in petroleum-based control containers.

At the end of the 10-week trial, three of the biocontainer types

[PLA-Lignin (90/10), PHA-DDGS (80/20), and Recycled PLA

(Resin only)] received appearance ratings that were equal to

those of the petroleum-based control, and the appearance of all

biocontainers in the trial was acceptable for the plant-container

units to be sold commercially. Instron tests of vertical and

horizontal crush strength of containers after their use in the

greenhouse for 10 weeks showed that all biocontainers in the

trial exceeded the strength of the petroleum-plastic control. In

our experiment evaluating the compostability of container ma-

terials in home compost systems, four of the injection-molded

container materials [PLA-Soy-BioRes (50/30/20), PLA-Soy

(60/40), PHA-DDGS (80/20), and PLA-Soy-BioRes (55/35/10)]
decomposed completely during the 12-week compost cycle and

another [PLA-BioRes (80/20)] decomposed 96%. The coated

paper-fiber container decomposed the least of the biocontainers

(28%), and the petroleum-based control showed no decomposi-

tion. We conclude that decomposition in home compost can be

a viable end-of-life option for many of these improved bioplastic

container formulations. All five of the highly compostable

biocontainers in our trial were sufficiently durable for produc-
tion of short- and medium-cycle greenhouse crops, and all five

were used to produce gerbera of equal quality to those grown in

standard petroleum-plastic containers. The use of compostable

injection-molded biocontainers could provide a substantial

improvement in sustainability for growers and consumers who

utilize composting in their cultural practices.

(288) Commercial Evaluation of Large,

Biopolymer-based Biocontainers for Herbaceous

Perennial Production

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Biocontainers may serve as effective alternatives to plastic

containers in the commercial container crops industry. The

objectives of this experiment were to quantify commercial

producer interest and willingness to use large biocontainers in

their commercial production systems, and quantify growth and

quality of herbaceous perennials grown in different biocontainers.

Seedlings of ‘Arizona Sun’ blanket flower (Gaillardia xgrandi-
flora Van Houtte) and ‘Pow Wow Wild Berry’ purple coneflower
(Echinacea purpurea L.), and three types of 1-gallon containers

were taken to five commercial grower facilities in the upper Mid-
west. Containers employed in this study included two types of

biopolymer-based biocontainers and a control: 1) 80% polylactic
acid (PLA) and 20% Biorest™ (BR); 2) biopolyurethane-coated paper fiber; and 9) petroleum plastic (control). Questionnaires that quantified producer perceptions and willingness to use, interested in different container attributes, and satisfaction were administered at different times during the experiment. When the majority of plants were flowering, growers rated the quality of the shoots, roots, and containers. Data collected included height, widest width, and perpendicular width; Growth Index (GI) was calculated. Shoots were harvested, dried, and shoot dry mass (SDM) was recorded. Grower affected GI, SDM, and shoot ratings of coneflower; GI and SDM of coneflower from grower C were 24% to 48% and 43% to 82% larger, respectively, compared to other growers. Container type and grower interacted to affect coneflower root and container ratings. For example, root ratings of coneflower grown in PLA/BR varied from 2.0–4.3 across growers, while variation across container types within grower only occurred for grower D. Container type and grower interacted to affect blanket flower GI, SDM, and container rating. Blanket flower GI and SDM were 29.9–30.8 and 11.5–12.2 g across containers for grower A, respectively, but differed within container type among growers. For example, GI and SDM of blanket flower grown in bio-polyurethane coated paper fiber containers at grower D were 43% and 74% larger than grower B, respectively, but did not differ across container types for grower D. Blanket flower shoot rating was 3.7–3.9 out of 5 across container types, and was not affected by grower or container type. Our results indicate that commercial producers can adapt these biocontainers to herbaceous perennial production schemes with few or no changes to their crop culture practices. Commercial producers should use this information if transitioning away from petroleum plastics to biocontainers in their large-container cropping systems.

**Postharvest Storage Conditions and Flower Life of Tulips**

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To maintain quality, tulips are commonly cold-stored prior to shipment and marketing. It is unknown, however, how this cold storage impacts flower quality. We investigated the effects of postharvest cold storage on carbohydrate status and flower life using two commercially important tulip cultivars, ‘Saigon’ and ‘Strong Gold’. At bud color stage, forced, potted plants were moved from the greenhouse at 17 ºC into dark storage at 1 ºC, or 7 ºC and were held for 1, 2, 4, or 7 weeks. After cold storage, plants were moved into a postharvest evaluation room at 20 ºC (12 h of light at 8–12 μmol·m-2·s-1) to assess flower life. Cold stored plants were compared to plants moved directly into the evaluation room. In both cultivars, plants stored at 7 ºC for 7 weeks had the shortest flower longevity. As duration of storage increased to 4 and 7 weeks and temperature to 4 ºC and 7 ºC, the flower life of ‘Strong Gold’ decreased more rapidly than ‘Saigon’. In both cultivars, starch decreased as temperature and duration of storage increased. Storage up to 1 week caused no significant reductions in flower life in ‘Saigon’, but any period of storage of ‘Strong Gold’ caused a decrease in flower life. For durations > 1 week, best flower quality resulted from storage at 1 ºC in both cultivars, and that storage at 4 ºC or 7 ºC should be avoided if possible. Future studies will focus on carbohydrate changes occurring upon transfer to a 20 ºC environment.

**Poster Session—Nursery Crops**

(297) A Study to Investigate the Effects of Aging and Pile Management on Processed Pine Bark

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Aged pine bark is a commonly used substrate component in the southeast United States. Aging is a modified composting process in which bark is piled in windrows for a period of time, usually six months to one year. Aging time can vary between bark suppliers, or even for the same supplier. Recently, demand for fresh pine bark instead of aged has increased because of its lighter weight, resulting in cheaper transportation costs. Little research has been done to investigate the differences between bark of various ages, with discrepancies in the literature about the effect aging has on nitrogen immobilization, fertilizer rates, irrigation, and potential toxicity. In addition to a lack of information on the differences between aged and fresh pine bark, there is no information regarding the effects of processing, material handling, or pile management on the end product quality. A long-term study was initiated to better understand the effects of aging and pile management on pine bark substrates. The study is being conducted at TH Blue, Inc., a pine bark supplier in Eagle Springs, NC. Fresh pine bark was processed and the fines were placed in three piles (replications) of 250 cubic yards each. Beginning at time 0 and every 4 to 5 weeks for a period of twelve months, stratified subsamples are taken from each pile at three different heights (top, middle, and bottom) at depths of 1’–4’ to account for variations in pile depth and height. The stratified subsamples are mixed into one composite sample for each pile replication to test the physical, chemical, and biological properties of the pine bark. Physical properties include pile dimensions, temperature, particle size distribution, total porosity, container capacity, air space, bulk density, wettability, white wood content, color, and thermal imaging. Chemical properties include pH, EC, total elemental analysis, and CEC. Biological properties include incubation experiments to determine nitrogen immobilization/mineralization, and seedling germination tests. With the conclusion of this study, the data generated can hopefully improve the...
(298) Fifty Shades of Gley—Using Munsell Soil Color to Assess Pine Bark’s True Colors
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Aged pine bark is a commonly used organic substrate component in the southeast United States. Growers often select bark they want to use by its color, smell, “feel,” and consistency in addition to physical and chemical properties. Color has been suggested as a sensory property to evaluate the aging process of composts and other organic materials, but its use as a characterizing parameter to assess the quality of pine bark substrates has not been investigated. The Munsell Soil Color system is frequently used to quantify and analyze the color of different soils. It consists of approximately 250 colored chips arranged on hue cards. Three coordinates - hue, value, and chroma - are used to describe the colors. Hue refers to the dominant spectral color, with red (R), yellow (Y), yellow-red (YR) green-yellow (GY), gray (GLEY), and white being the dominant hues in communicating soil color. The Munsell soil hue cards include 10R, 10YR, 2.5Y, 2.5YR, 5Y, 5YR, 7.5YR, 10Y – 5GY, GLEY 1 and 2, 5R, 7.5R, and white. Value indicates the degree of lightness or darkness of a color on a gray scale ranging from black to white. In the Munsell color charts, value ranges from 0 (pure black) to 10 (pure white). Chroma is the purity or saturation of a color. Chroma ranges from 0 (neutral colors) to 8 (strongest color) in the Munsell color system. A long term study was implemented to quantify the effects of aging and pile management of pine bark substrates. Fresh pine bark was processed and the ½” fines were placed in three replicated piles with 250 cubic yards of material per pile. As part of a larger project looking at the physical, chemical, and biological properties of pine bark during the aging process, the use of the Munsell Soil Color book is being utilized as a tool to assess color changes. Over the course of seven sampling dates we observed that the color of the bark darkened with age. This is expressed in the decreasing value/chroma coordinates of the Munsell hue cards (read as hue, value/chroma), which were 5YR, 3/4; 2.5YR, 3/4; 5YR, 2.5/2; 2.5YR 2.5/2; 5YR, 2.5/1; 2.5YR, 2.5/1; and 2.5YR, 2.5/1 on day 0, 52, 84, 112, 146, 173, 211, respectively. The Munsell Soil Color system shows potential as a tool to help better quantify the use of color as a parameter to assess the pine bark aging process.

(299) Effect of Rice Hull Mulch on Nutrient Concentration of Fertilized Irrigation Water
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Parboiled rice hulls are effective mulch for controlling weeds in nursery containers. A layer of rice hulls between 1.25 and 2.5 cm deep has been shown to provide effective control of liverwort (Marchantia polymorpha), bittercress (Cardamine flexuosa), and creeping woodsorrel (Oxalis corniculata). There is some speculation that the rice hull layer may affect the nutrient content of fertilized irrigation water, either removing nutrients, such as nitrogen (N), or adding other nutrients, including phosphorus (P) and potassium (K). The objective of this study was to determine how increasing depth of rice hull mulch affected the nutrient concentration of fertilized irrigation water as it passed through the mulch layer. Rice hulls were placed in Buchner funnels (13.1 cm i.d., 6.6 cm tall) at a depth of 0, 0.6, 1.2, or 2.5 cm. Each funnel was placed on a greenhouse bench equipped with an overhead irrigation system with fixed pattern nozzles. Each funnel was placed over a 400 mL glass jar so that all irrigation water passing through the funnel would collect in the jar beneath. Furthermore, only irrigation water passing through the funnel (and no other extraneous irrigation water) would enter the jar. A water soluble fertilizer (20N-4.4P-16.6K) was injected at 150 mg·L⁻¹ N into the irrigation water. The irrigation system was run for 10 min per day for 9 days. Water samples from each jar were collected after each irrigation event and refrigerated until analysis with ion chromatography for concentration of NO₃⁻, NH₄⁺, PO₄³⁻, and K⁺. All rice hull layers reduced NO₃⁻ concentration on day 1 by approximately 35%. Thereafter, only the 2.5 cm rice hull layer reduced NO₃⁻ concentration, but only for four additional days. A similar response was observed for NH₄⁺ concentration. All rice hull treatments resulted in higher PO₄³⁻ and K⁺ concentrations than the non-mulched controls throughout the 9-day experiment. Parboiled rice hulls are a known source of PO₄³⁻ and K⁺ when used as a substrate amendment. Additional PO₄³⁻ and K⁺ provided by the rice hull treatments varied throughout the experiment, but generally ranged from a 20% to 30% increase compared to the non-mulched controls. These data demonstrate that fertilizer nutrient levels are affected by rice hull mulch layers, although nutrient concentrations are not reduced to the extent that rice hull mulch would reduce plant growth. Specified Source(s) of Funding: Horticulture Research Institute
Our results indicate that notable variation in growth and caliper, as well as foliar N, P, K, Ca, B, Cu, Mg and Mn content, leaf dry weight, root dry weight, stem length, SPAD, and stem the four provenances differed in leaf number, stem dry weight, and consistently branched at the cotyledonary node. Plants from produced single stems, whereas those from one provenance in indigenous populations, seedlings from three provenances and development. Although maternal plants were shrub-like commercially important and overall plant growth was robust. In nitrogen source, the differences in means were not likely to be localized spatial scale, and that fertilizers containing either NH₄⁻N or NO₃⁻N affected growth and development of plants in container culture. Plants growing in a substrate of 1:1 (perlite:vermiculite) were supplied with nitrogen and other nutrients using modified and balanced Hoagland solutions. The pH of each solution was adjusted to 4.5 or 6.5, for a total of six treatment combinations. Seedlings were fertilized regularly for 61 days. Substrate pH was influenced by nitrogen form, but not by solution pH. Nitrogen form did not affect root dry weight, leaf dry weight, and stem length. Seedlings supplied with nitrogen in the form of NO₃⁻N or NH₄⁻N alone had slightly greater stem caliper, stem dry weight, SPAD, and foliar Fe content than those supplied with NO₃⁻N alone. Seedlings supplied with NO₃⁻N had marginally greater leaf number and foliar Al, Mg, and Ca than those provided with NH₄⁻N. Even though some traits varied by nitrogen source, the differences in means were not likely to be commercially important and overall plant growth was robust. In contrast, seedling provenance had a large impact on plant growth and development. Although maternal plants were shrub-like in indigenous populations, seedlings from three provenances produced single stems, whereas those from one provenance consistently branched at the cotyledonary node. Plants from the four provenances differed in leaf number, stem dry weight, leaf dry weight, root dry weight, stem length, SPAD, and stem caliper, as well as foliar N, P, K, Ca, B, Cu, Mg, and Mn content. Our results indicate that notable variation in growth and development exists among provenances of A. spicata, even within a localized spatial scale, and that fertilizers containing either NH₄⁻N or NO₃⁻N are suitable for their production in containers.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture

(301) Rooting of Young Interior Douglas-fir Seedlings in Response to a Commercial Liquid Extract of the Marine Macroalga Ascophyllum nodosum

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Interior Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. glauca (Beissn.) Franco) inhabits the interior mountain ranges and plateaus of western North America from Canada to Mexico. Ecosystem-based bioclimate envelope modelling for British Columbia, Canada, predicts an expansion of the interior Douglas-fir climate region within 50 years. Thus, reforestation with interior Douglas-fir will likely increase ahead of this shift.

In containerized nursery culture, abundant lateral rooting in the upper third of peat plugs can be difficult to attain. Our goal is to provide an inexpensive treatment to improve root-system quality in the nursery, and thus increase initial root growth after planting, which is vital for seedling survival and will become more critical under a changing climate. Earlier, we reported an increase in spring root growth of Pinus contorta Doug. ex Loud. var. latifolia Engelm. and Picea glauca (Moench) Voss seedlings in response to a liquid extract of Ascophyllum nodosum (L.) Le Jolis (ANE). The objective of the initial trial, reported here, was to determine whether and, at what rate, ANE would increase rooting in young interior Douglas-fir seedlings. We tested a seedlot donated by the British Columbia Ministry of Forests, Lands and Natural Resource Operations that is under investigation in their Assisted Migration Adaptation Trial. We imbibed seed overnight, placed them in dark, cold stratification (4 °C) for 21 d before moving them to a germination cabinet (30/20°C D/N, 8-h photoperiod, 85% RH) for 7 d. Next, we suspended resultant germinants in vials filled with ANE in deionized water at the following rates (mL/L): 0, 0.5, 1.0, 1.5, and 2.0. We grouped vials for each rate into separate racks, before randomly arranging racks on heating mats (24 °C) under full-spectrum grow lights (90 μmol·m⁻²·s⁻¹, 16-h photoperiod). We observed germinants/seedlings for rooting after 28 and 56 d. After 28 d, rooting was not evident at any ANE rate. After 56 d, rooting exhibited a response curve to ANE from stimulation through inhibition. Root-system length was increased by 135% at the optimal rate (1.0 mL/L) compared with control. Moreover, secondary roots were initiated on 100% of primary roots at the optimal rate compared with 11% in control. Furthermore, secondary root number was increased 680% at the optimal rate compared with control.

(302) Root Pruning and Auxin Application Alter Root Development of Hickories

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Diversification of taxa is an important goal of those who manage urban landscapes. Some otherwise desirable species have not been promoted for use due to reports of challenges associated with their production or establishment. A reputation for coarse root systems with dominant tap roots, and for slow shoot development among seedlings, has limited the use of hickories Carya Nuttall. We examined effects of root pruning and auxin on root and shoot development of seedlings of several species of hickory that are adapted to diverse natural habitats. Our hypothesis was that pruning of the primary radicle shortly after seed germination and subsequent treatment with auxin would increase root branching without curtailing development of the shoot. Carya aquatica Nuttall, Carya cordiformis K. Koch, Carya laciniosa Loudon, Carya ovata K. Koch, and Carya tomentosa Nuttall were treated by removing 7 mm of the primary radicle followed immediately by applying the auxin indole-3-butyric acid (IBA)

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

Poster Presentations

(320) Evapotranspiration Adjustment Factors (ETAF) of 30 Large Landscape Plantings in Six Climate Zones in California
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As of 31 Mar. 2016, over 90% of California continued to experience moderate to severe drought for the fifth consecutive year necessitating further conservation of an already limited water supply. The goal of our four year California Department of Water Resources (DWR) research project is to measure water use and reduce water waste at 30 large urban landscapes in six climate zones throughout California that include a variety of ornamental plants with diverse water use requirements that are growing under varying leaf area densities and microclimates. Findings to date indicate: properly functioning irrigation systems with matched heads, proper spacing, proper pressure, and unclogged heads can significantly reduce landscape water waste; distribution uniformity of sprinkler systems can be increased without major redesign and installation efforts by switching to rotary sprinkler heads; landscapes consisting solely of cool season turfgrass use the most water of all planting configurations studied; well mulched landscapes consisting of very low and low water using hydrozones irrigated according to their specific water needs use the least amount of water. The average (mean) overall change in water use across the 30 sites from 2014 to 2015 was –0.286 ETAF. The average (mean) decrease in water use at the twenty five sites which used less water in 2015 was –0.451 ETAF while the average (mean) increase in water use at the five sites which used more water was 0.12 ETAF.

Specified Source(s) of Funding: California Department of Water Resources (DWR)

(321) A Novel Approach for Determining Root Biomass in Plant-based Research
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In plant-based research, root biomass is often recorded. To determine root dry weight, roots are traditionally separated from substrate. Methods include compressed air, pressurized water spray, and water baths. Despite use of screens, portions of roots are typically lost during separation processes. If root balls are dried and weighed at harvest and dry mass of substrate is known root dry weight could be extrapolated. On 5 Oct. 2015, thirty-five 15-cm (1.6 L) containers were filled with 380 g substrate per container. Five containers were randomly selected and placed in a forced-air drying oven at 60 °C for one week to determine average dry mass of substrate per container. One *Lantana camara* ‘Chapel Hill Gold’ plug was transplanted from 60 count flats into each of 20 containers and topdressed with 6 g Osmocote Plus 15−9−12. The remaining ten filled containers were maintained with no plant to verify that no substrate was lost during the experiment due to hand watering which was applied as needed. On 1 Dec. 2015, shoots were separated from root balls. Roots from ten randomly selected plants were separated from substrate by washing root balls in 5-gallon buckets filled with water until roots were relatively clean of substrate. Harvested shoots and roots were dried in a forced-air oven at 60 °C and weighed. The ten remaining root balls and ten filled containers with no plants were placed in a forced-air oven at 60 °C for five days and weighed. Shoot and root weights from both groups were analyzed using one-sample t-tests. Root dry weight harvested by washing averaged 4.29 g, while root dry weight calculated by drying root balls averaged 9.35 g (P < 0.0001). Shoot dry weight was similar among both groups (P = 0.8809). Although plants were similar in size, less root mass was measured by washing roots than by calculating root mass based on root ball dry weight. These data suggest significant root loss due to washing. Starting with a known mass of dry substrate and weighing root balls at experiment termination may improve accuracy when determining root biomass.

(322) The Effect of Two Plants Grown in Calcined Clay with Activated Alumina on Nitrogen and Phosphorus Removal in Greenhouse Natural Swimming Pool Mesocosms
Margaret Hoffman*
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Natural swimming pools (NSPs) are recent technological introductions to North America, designed to provide an attractive...
landscape amenity that also serves as a chemical free swimming pool. Based on constructed wetland technology, natural swimming pools use biological filtration, a designed, intentional hydraulic system, and an impermeable liner to separate the system from the surrounding natural hydrologic cycle. Two ornamental wetland plants, Iris versicolor, blue flag iris, and Canna xgeneralis, canna sp., were tested for their ability to produce aboveground biomass in the low nutrient environment of an NSP and for their nutrient removal capabilities. Appropriateness of the substrate materials, a mix of calcined clay, sand and alumina, was assessed for plant establishment and nutrient storage capabilities. The experiment included 24 units and 3 treatments: 1) blue flag iris, 2) canna sp, and 3) unvegetated, with 8 units each. All treatments are divided into 2 conditions, free water surface (FWS) and subsurface flow (SSF), with 4 units in each condition. NO3 and phosphorus levels in the NSPs water column should be less than 30 mg/L NO3 and 0.01 mg/L P. These are the levels recommended by the 2006 German FLL Guidelines for private NSP design and operation. Treatment effect for plant species and final NO3 levels in the pool water were highly significant (P < 0.001). Canna removed larger amounts of NO3 than iris, probably due to greater biomass production. The correlation of biomass and NO3 removal was highly significant (P < 0.001), using Pearson's correlation. Above ground biomass was a significant storage compartment in both Canna sp and blue flag iris, demonstrating the importance of harvestable biomass removal. P removal experienced in all three treatments supports the hypothesis that activated alumina combined with calcined clay is an effective media for adsorption of P in a NSP system. All treatments reached treatment goals for P removal and experienced greater than 99% removal of influent P. In all treatments final P measured less than the recommended level of 0.01 mg/L. Both vegetated treatments with the calcine clay/alumina/sand substrate supported suitable biomass production and nutrient storage. The unvegetated treatment met the recommended levels of P removal but did not reach the recommended NO3 level of < 30 mg/L.

(323) Phytotoxicity of Herbicides, Fungicides, and Insecticides/Acaricides on Ornamental Horticultural Crops in Southeastern United States for Interregional Research Program (IR-4)

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The Interregional Research Project (IR-4) is a joint USDA-ARS and Land Grant Institution program that has been the primary resource in the United States for facilitating registration of sustainable pest management technology for specialty crops including fruits, vegetables, nuts, herbs, spices, and non-food ornamental horticulture crops. The IR-4 Ornamental Horticulture Program on the U.S. southeastern Coastal Plain focuses its research on phytotoxicity experiments with herbaceous annual/perennial and woody ornamentals. Experiments are designed to measure phytotoxicity of specific pesticide/commodity combinations that address insects, weeds, and plant diseases of ornamental horticulture crops in the southeastern United States. In the last five years, we have completed 59 ornamental horticulture phytotoxicity trials on 20 genera including Begonia, Buddleia, Buxus, Hedera, Hemerocallis, Hosta, Hydrangea, Ilex, Juniperus, Lantana, Ligustrum, Liriopoe, Pinus, Portulacia, Raphiolepis, Rhododendron, Spiraea, Verbena, Viburnum, and Zinnia. These included 15 herbicide trials using 6 herbicides to treat 10 ornamental crops and applied as either a broadcast granular or “over the top” liquid. It also included 38 fungicide and 6 insecticide combinations using 8 fungicides and 3 insecticides to treat 26 ornamental crops using foliar applications. Results indicated no injury among any of the fungicide and insecticide treatments, but significant differences in phytotoxicity between the nontreated controls and several of the herbicide treatments. Regional data from around the United States are compiled into summaries and ultimately submitted to manufacturers, who review and incorporate the information into technical literature and product labels. Over 35,000 crop uses have been registered since 1977, when the Ornamental Horticulture Program was established.

(324) Colorado Multi-site Woody Plant Trials

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Options for shade tree selection in Colorado are limited due to climate, soils and disease and insect issues. Late and early frosts, dry winters with fluctuating temperatures and calcareous alkaline soils have traditionally limited the diversity of species that can successfully be grown in many parts of the state. Increasingly limited and expensive water resources coupled with the dry climate of much of the state also make many mesic taxa less desirable. The at the same time, many commonly planted species have been affected by serious disease or insect issues such as: Dutch elm disease, thousand cankers disease, and emerald ash borer. In response to this the multi-site woody plant evaluation program in Colorado was started in 2002 at five different research and nursery sites throughout Colorado. Since 2002, we have done twelve plantings evaluating a total of sixty-four (64) different taxa. Trial plants are evaluated based on survival, growth, ornamental appeal and their potential to be invasive over a five-year period. In 2002, we started with five co-operating sites including three private sector nurseries, Boxelder Creek Nursery (south of Hudson, CO); Harding’s (Calhan); Little Valley (Brighton) and two CSU research sites, the Horticultural Research Center in Fort Collins (now ARDEC South) and Western Colorado Research Center–Orchard Mesa in Grand Junction. Originally ten replications of each plant were planted in a randomized block arrangement. A major hail storm...
in 2009 destroyed the planting at Boxelder Creek and we lost that site. In 2015, we moved the Harding’s Nursery site to the Colorado Agricultural Leadership Foundation near Castle Rock, CO. In late 2008, we held an informational meeting with Plant Select® members and other interested personnel to re-evaluate the program and plan for the future of this research. From this meeting, it was concluded that the research should continue but several changes were suggested. Industry personnel at the trial sites will take more observational data throughout the growing season. Also, standard nursery practices such as pruning will be done on all the trial plants to better evaluate the overall market potential. Also, the number of replications was reduced from ten to eight. Some of these woody plants have been recommended or introduced through the Plant Select® program including Acer tataricum ‘GarAnn’PP15023 (Hotwings® Tatarian Maple); Arctostaphylos x coloradoensis (Mock Bearberry Manzanita); Arctostaphylos x coloradoensis (Panchito Manzanita); Heptacodium miconioides (Seven-son Flower) and Juniperus scopulorum ‘Woodward’ (Woodward Juniper). Planting continues yearly.

Specified Source(s) of Funding: Plant Select and Colorado Horticulture Research and Education Foundation

(325) Determining the Fungal Associations of Two Co-occurring Invasive Orchids in Miami–Dade County

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Fungal distribution within the environment can be heavily dependent on microhabitat conditions, which create mosaic-like fungal networks within that environment. Recent studies showed that orchids that occur within close proximity to each other are likely to share similar fungi associations (McKendrick et al., 2002; McCormick et al., 2004; Xing et al., 2013). Two invasive species Eulophia graminea and Oeceoclades maculata are known to co-occur and are rapidly spreading in municipal mulch sources in Miami-Dade County. In this study, I determine whether these two introduced species are associating with similar groups of fungi, by sampling the fungi from roots of plants from two distinct populations and habitat types in Miami (Fairchild Tropical Botanic Garden and Boystown Pineland County Park).

(326) Effect of Mulching and Irrigation on Growth and Disease Incidence of Dwarf Boxwood

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Buxus sempervirens L. ‘Suffruticosa’ (dwarf boxwood) is a popular ornamental for landscape use that is currently suffering from decline caused by plant pathogens such as Phytophthora species. High soil moisture is associated with this decline. Excessive irrigation and mulch may keep soil moist thus promoting diseases and inhibiting growth. In this study, effects of pine bark mulch, irrigation, and inoculation with Phytophthora nicotianae Breda de Haan on dwarf boxwood were examined. Plants were treated with two mulch levels (no mulch and 5-cm pine bark) and three irrigation levels (no irrigation, 2.5 cm per week, and 5 cm per week), and half of plants were inoculated. Plants were rated for disease symptoms after inoculation. Only plants inoculated with P. nicotianae showed significant reduction in growth, and they gradually developed symptoms of Phytophthora root rot. Dwarf boxwood that showed pathogenic symptoms had low to zero photosynthetic capacity. P. nicotianae was recovered from crowns and roots of symptomatic plants. Additional irrigation and pine park mulch did not have significant effects on dwarf boxwood in the first year of experiment, which was possibly caused by unusually high precipitation in the growing season. Extra irrigation and pine bark had no significant effect on disease incidence or growth.

(327) National Clean Plant Network for Roses

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At the urging of the grape and fruit tree industries, the National Clean Plant Network (NCPN) was established to provide high quality asexually propagated plant material free of targeted plant pathogens and pests for growers in the United States. In 2008, the NCPN was initiated with grapes and fruit tree crops. The addition of citrus, berries, and hops in 2010 and roses and sweet potatoes in 2015 followed this. Each specialty crop has its own commodity network composed of representatives from industry, academia, extension, state government and other interested experts. This program supports translational research, education and extension initiatives to maintain the network’s high quality collections and strengthen its services. Since being established in 2015, the National Clean Plant Network for Roses (NCPNR) has been working to augment, renovate and improve the current rose collection at the Foundation Plant Services (Davis, CA), to assess the frequency of viruses in roses in the USA, to develop
educational materials, and to establish the best protocols for determining the pathogen status of a rose.

Specified Source(s) of Funding: National Clean Plant Network

Poster Session—Viticulture and Small Fruits

(259) Abscisic Acid and Kaolin for Heat Stress Mitigation during Strawberry Plug Transplant Establishment

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Although Florida is the leading producer of winter strawberries (Fragaria xananas Duch.) in the United States, in recent years the Florida strawberry industry has faced increasing competition for the winter market from Mexico and California. Shifting strawberry production in Florida to earlier in the season has been suggested as a means of increasing profits in a challenging market. However, earlier planting would expose transplants to higher soil and air temperatures and heat tolerant cultivars are not currently available. The objective of the present research was to evaluate the effects of s-abciscic acid (s-ABA) and kaolin on the mitigation of heat stress during early-season establishment of ‘Florida Radiance’ strawberry plug transplants. The s-ABA was applied at 250, 500, 750, 1000 mg/L as a five second root dip just prior to transplanting. Kaolin (56 kg/ha) was applied as either a single spray application shortly after transplanting or as two sequential spray applications of 56 kg/ha each: the first at the time of the single spray application and the second at 7 days after planting. Nontreated plants were included as a control. Plant vigor, plant survival, chlorophyll content, leaf number, leaf area, crown size, days to first flower, shoot and root dry weights, and fruit yield were assessed. Rates of s-ABA higher than 250 mg/L had pronounced adverse effects on vegetative parameters, delayed flowering and fruiting, and decreased fruit yield. Although a single application of kaolin significantly increased yield compared to the control, the highest strawberry yield was obtained with the double application of kaolin. The lowest s-ABA rate and the double application of kaolin appear to have the best potential for mitigating heat stress during strawberry plug transplant establishment.

Specified Source(s) of Funding: Borlaug Higher Education for Agricultural Research and Development

(260) Effect on Yield and Vegetative Growth of Prohexadione Calcium Treatments to Southern Highbush Blueberry ‘Emerald’ and ‘Star’

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Summer pruning or hedging is performed postharvest for southern highbush (SHB) blueberry to control height and stimulate new growth for next season’s production. Hedging is usually finished by mid-May to early June, leaving ample growing season to set reproductive buds and allow for growth, which is often excessively vigorous. The objective of this study was to reduce vigorous regrowth with the gibberellin biosynthesis inhibitor prohexadione-Ca (commercial formulation Apogee, BASF Research Triangle, NC). The product was applied to the foliage of ‘Emerald’ and ‘Star’ post-hedging in 2014. On each date, 24 July and 5 Aug, a solution of 122 ppm active ingredient (415 g/935.3 L/ha label rate) was applied. Shoots were measured and fruiting buds counted during dormancy and whole bush yield were collected at color change of the fruit in 2015. Shoot growth in ‘Emerald’ showed a numerical (14%) reduction in shoot length compared to the untreated plants. Bud count and yield were not significantly affected in either variety. However, late summer observations showed reduced shoot elongation, which suggested that prohexadione-Ca affected both ‘Star’ and ‘Emerald’ shortly after application; however, the impact was short-lived as vigorous growth resumed in the fall. In subtropical climates, late fall growth may be exposing succulent shoots to freezing events, which can damage the plant and cause open wounds that are points for disease infection. This work suggests prohexadione-Ca at two applications were not sufficient for growth suppression and there is need to identify cultivar specific response.

Specified Source(s) of Funding: Georgia Blueberry Growers Association

(261) Screening and Marker Selection for Anthracnose Susceptibility in Florida Blueberry Cultivars

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Blueberries are an important commercial crop in the United States, with over 550 million pounds produced in 2014. Florida has become an important supplier of blueberries for the fresh market, particularly during the period from March to May. The success of Florida growers is due in large part to the development of southern highbush blueberry (SHB) cultivars (Vaccinium corymbosum) that need significantly less chilling hours for fruit production than typical temperate cultivars. These SHB cultivars
and the mild subtropical winter climate allow growers to harvest when the price point is high. However, the humid summer conditions present with the subtropical climate often result in a high degree of disease incidence and severity. For example, anthracnose, caused by the Colletotrichum fungal pathogen, is a disease typically associated with postharvest fruit rots, but can also produce stem lesions and dieback in susceptible cultivars. This disease has recently been reported on two SHB cultivars ('Flicker' and 'Scintilla') grown primarily in central Florida, and the degree of susceptibility of other cultivars is currently unknown. Identification and confirmation of parents that are not susceptible to anthracnose stem dieback would facilitate crossing decisions for SHB breeding. The objectives of this research were to screen several SHB cultivars for susceptibility to anthracnose and the degree of susceptibility of other cultivars is currently unknown. Identification and confirmation of parents that are not susceptible to anthracnose stem dieback would facilitate crossing decisions for SHB breeding. The objectives of this research were to screen several SHB cultivars for susceptibility to anthracnose stem dieback. Screening for anthracnose susceptibility was performed using a spray inoculation of a virulent Colletotrichum isolate collected from field infections on ‘Flicker’. The isolate solution was prepared at a 10\(^{-6}\) per mL concentration, and sprayed onto both whole plants under greenhouse conditions. Incidence was determined by the presence of stem lesions on any new shoot. Severity of disease over time was assessed by measuring lesion length with a digital caliper for a period of five days from first observation of disease symptoms. ‘Flicker’ plants were utilized as a positive control for disease incidence and severity.

(262) Cold Hardiness of Southern Highbush Blueberry (Vaccinium corymbosum L. Interspecific Hybrid) Floral Buds

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Blueberry production in southeastern United States utilizes low chill cultivars of highbush blueberries, which are susceptible to freeze damage. Tolerance to freezing temperatures of floral buds in northern highbush blueberry (NHB; V. Corymbosum L.) has been previously described; however, southern highbush blueberry (SHB) has not been well characterized. The objective of the study was to determine SHB’s sensitivity to freeze in excised floral buds (EFB) and floral buds attached to the stem (AFB) through tissue freezing methods, differential thermal analysis (DTA) or controlled temperature thermal analysis (TA). Floral buds of ‘Emerald’ and ‘Farthing’ were sampled through dormancy to evaluate when the price point is high. However, the humid summer conditions present with the subtropical climate often result in a high degree of disease incidence and severity. For example, anthracnose, caused by the Colletotrichum fungal pathogen, is a disease typically associated with postharvest fruit rots, but can also produce stem lesions and dieback in susceptible cultivars. This disease has recently been reported on two SHB cultivars ('Flicker' and 'Scintilla') grown primarily in central Florida, and the degree of susceptibility of other cultivars is currently unknown. Identification and confirmation of parents that are not susceptible to anthracnose stem dieback would facilitate crossing decisions for SHB breeding. The objectives of this research were to screen several SHB cultivars for susceptibility to anthracnose stem dieback. Screening for anthracnose susceptibility was performed using a spray inoculation of a virulent Colletotrichum isolate collected from field infections on ‘Flicker’. The isolate solution was prepared at a 10\(^{-6}\) per mL concentration, and sprayed onto both whole plants under greenhouse conditions. Incidence was determined by the presence of stem lesions on any new shoot. Severity of disease over time was assessed by measuring lesion length with a digital caliper for a period of five days from first observation of disease symptoms. ‘Flicker’ plants were utilized as a positive control for disease incidence and severity.

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(263) Suitable Sources of Nitrogen and Potassium Fertilizer for Fertigation of Northern Highbush Blueberry

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Many blueberry growers are switching from broadcasting granular fertilizers to using fertigation through a drip irrigation system. Fertigation increases growth and production without increasing the need for more fertilizer. The objective of the present study was to evaluate different liquid sources of N and K fertilizers for fertigation in northern highbush blueberry (Vaccinium corymbosum L.). The study was conducted in a greenhouse using potted plants of ‘Duke’ blueberry. Treatments included a combination of the two soil types [optimum (4.9) and high pH (6.2)], two liquid K sources [(potassium sulfate and potassium thiosulfate (KTS)), five liquid N sources [urea, ammonium sulfate, ammonium thiosulfate (ATS), urea ammonium nitrate (UAN), and urea-triazione (slow-release N); 0.10 g·L\(^{-1}\) N each], and five K rates (0, 0.05, 0.10, 0.15, and 0.20 g·L\(^{-1}\)). The plants were fertigated three times per week with each combination of K and N fertilizer, plus a modified Johnson’s solution to avoid limitations of other nutrients. Fertigation with ATS and/or KTS...
(264) Descriptive Sensory Attributes of Arkansas Blackberries Harvested Multiple Years
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Fresh blackberries (Rubus subgenus Rubus) can have unique physiochemical and sensory attributes that vary by year. The physiochemical and sensory attributes of 10 blackberry genotypes were evaluated in 2014 and 2015. Five blackberry cultivars (Natchez, Osage, Ouachita, Prime-Ark® 45, and Prime-Ark® Traveler) and five advanced selections (A-2418, A-2434, A-2450, A-2453, and A-2491) were harvested at the shiny-black stage of maturity from the University of Arkansas Fruit Research Station, Clarksville. In 2014 and 2015, ‘Natchez’ was the largest berry (12.6–14.3 g) and A-2491 had the highest soluble solids (10.9% to 11.0%), while A-2418 had the highest titratable acidity (1.4% to 1.5%) and the lowest soluble solids (6.6% to 8.1%). A trained descriptive panel (n = 8–9) evaluated fresh blackberry attributes including appearance (size of berry and glossiness), basic tastes (sweet, sour, and bitter), overall aromatics, and firmness using a 15-point scale (0 = less and 15 = more of the attribute). The interaction between genotype and year was significant for the descriptive attributes, size of berry, glossiness, sweetness, sourness, and overall aromatics, but the interaction was not significant for the firmness attribute. All blackberries evaluated in 2015 were more firm than 2014, and A-2453 was the most firm and ‘Natchez’ the least. The year of production impacted the attributes of some of the genotypes. In 2014 as compared to 2015, A-2450, A-2491, ‘Natchez’, and ‘Prime-Ark® 45’ had larger berries; A-2450 was glossier, A-2434, A-2491, ‘Natchez’, and ‘Prime-Ark® Traveler’ were sweeter, ‘Natchez’ and ‘Prime-Ark® 45’ were less sour; and A-2418, A-2453, ‘Osage’, and ‘Prime-Ark® 45’ had higher overall aromatics. Panelists were not able to detect differences in sweetness, sourness, or overall aromatics of blackberry genotypes in 2014, glossiness in 2015, or bitterness in either year. In 2014 and 2015, the descriptive panel scored ‘Natchez’ as the largest berry, and A-2453 the smallest, which corresponded to the berry weights. In 2014, A-2453 was the glossiest berry and A-2434 the least glossy. In 2015, A-2491 was the sweetest, A-2418 the least sweet, A-2450 the most sour, A-2453 the least sour and lowest overall aromatics, and ‘Natchez’ the most overall aromatic. Identifying the descriptive attributes for blackberries can be used to determine commercial potential and identify attributes that are consistent each year of production.

Specified Source(s) of Funding: Fluid Fertilizer Foundation, Tessenderlo Kerley Inc.

(265) Application of Biodegradable Mulches in Day-neutral Strawberry Grown in Western Washington
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Biodegradable mulches (BDMs) were introduced as an alternative to polyethylene (PE) mulches, which have economic and environmental challenges regarding costly removal and disposal. Biodegradable mulches may provide the same horticultural benefits as PE mulches, but are engineered to degrade in soils upon incorporation. Yet, BDMs have undergone limited testing, including with day-neutral strawberry (Fragaria xananassa) typically grown with PE mulch in plasticulture. The objective of this study was to evaluate whether BDMs are suitable for day-neutral strawberry production, with regional specificity to western Washington. To accomplish this, a randomized complete block split plot experimental design was established in Spring 2014 and 2015 at the Washington State University Research and Extension Center located in Mount Vernon, Washington. The study consisted of five main plot treatments, replicated four times. Treatments included: 1) a starch based BDM; 2) a prototype BDM; 3) a cellulose based BDM; 4) a PE positive control; and 5) a bare ground negative control. Cultivar was the split plot factor and consisted of ‘Albion’ and ‘Seascape’. Data collected includes crop yields, in-season mulch deterioration and intactness [recorded as percentage visual intactness (PVI)], and in-soil mulch degradation. Yields were on average greater for ‘Seascape’ grown with PE mulch, while ‘Albion’ was less sensitive to the mulch treatments. In both years of the study, yields were similar among the starch, prototype, and cellulose BDMs for ‘Seascape’ and ‘Albion’, while overall yields tended to be reduced for both cultivars in the bare ground plots. For PVI, the starch and cellulose BDMs performed similarly in 2014 and together averaged 90% PVI compared to 98% PVI for the PE control by 30 September (the last date of PVI data collection in 2014 and 2015). The cellulose BDM deteriorated more

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

Specified Source(s) of Funding: Specialty Crop Block Grant from the Arkansas Agriculture Department, U.S. Department of Agriculture (14-SCBGP-AR005)
rapidly in 2015, largely due to the effects of strong winds, and had a PVI of 64% by 30 September. The starch BDM and PE mulch performed similarly in 2015, with 93% and 97% PVI by 30 September, respectively. The prototype BDM deteriorated rapidly in 2014 (7.5% PVI by 30 September) and was replaced with a different formulation by the manufacturer in 2015 that had longer persistence in the field (62% PVI by 30 September). Evaluations of in-soil mulch degradation are ongoing. Results to date demonstrate BDMs perform differently based on their formulation, but are suitable for day-neutral strawberry production in western Washington.

Specified Source(s) of Funding: WSU’s Emerging Research Issues Internal Grant Program

(266) Commercial Extract from the Brown Seaweed Ascophyllum nodosum (Acadian®) Improves Yield and Quality of Hydroponically Grown Strawberries

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While the vast majority of commercial strawberries are grown in the field, greenhouse production of strawberries is becoming more common especially in European countries such as the Netherlands, Belgium, and Italy. Greenhouse strawberry production is attractive to many growers as it allows them to produce berries out of season and obtain higher prices. And because of environmental and availability issues of using soil fumigants for field grown production, many growers are looking for alternative production systems. A greenhouse experiment at the Dr. James S. Craigie Research Center in Cornwallis, Nova Scotia was designed to test the effects of Acadian® extract (a derivative from Ascophyllum nodosum) in the production of hydroponically grown strawberries (Fragaria xananassa, cv. Albion). Ascophyllum nodosum seaweed extract (ANE) treatments in combination with a standard hydroponic fertilizer were applied to the root systems of strawberry plants in NFT systems. Three rates of ANE were tested and results were compared to an untreated control. Significant improvements in early root and leaf establishment were observed in ANE treated plants. In addition, fruit number increased by 38% and °Brix from 2 to 12%. Improvements in leaf and fruit calcium levels also increased by as much as 10% in ANE treated plants. Insufficient calcium is known to cause tip leaf burn and poor fruit development in strawberries so this is an important finding. These results indicate that ANE applications increase yields and improve the quality of hydroponically grown strawberries, which ultimately improves the economic return to the user.

(267) Evaporative Cooling with Sprinklers to Reduce Heat-related Fruit Damage in Northern Highbush Blueberry

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Hot and sunny weather can cause a considerable amount of fruit damage in blueberries and results in millions of dollars of crop loss each year. The objective of this study was to evaluate the efficacy of using sprinklers to reduce the damage. The study was conducted for 2 years in a mature planting of northern highbush blueberry (Vaccinium corymbosum L. ‘Elliott’) located in western Oregon. Treatments included sprinkler irrigation (at night) and cooling when daytime air temperature reached set points of either 90 °F or 95 °F, sprinkler irrigation (at night) with no cooling, and drip irrigation with no cooling. For cooling, sprinklers were turned “on” for 15 minutes every hour until ambient air temperature dropped below the set point. Heat damage occurred primarily on sun-exposed berries and happened at both green and blue stages of fruit development. Early damage resulted in poor fruit color at harvest and produced large crevices on the berry surface. Berry temperatures were usually higher than the air temperature between 1000 and 1800 HR and reached up to 117 °F in sun-exposed clusters and 100 °F in shaded clusters. Berry temperatures dropped to <90 °F within the first 15 minutes of cooling and never exceeded ambient air temperature during the cooling cycle. While the percentage of fruit with heat damage was low even without cooling (<2%), cooling reduced the damage to nearly 0% each year, and increased the size of the berries. However, cooling had no effect on yield, fruit firmness, soluble solids concentration, titratable acidity, thickness of the waxy bloom on the fruit, or concentration of phenolic compounds in the fruit. Based on these results, cooling should begin at the “late green fruit” stage at critical temperatures ≥ 95 °F.

Specified Source(s) of Funding: Oregon Blueberry Commission

(269) Effects of Supplemental LED Light on a Strawberry Plant on the Bottom Bed When Cultivated on a Two-floor Bed System

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Over the past decade in Republic of Korea, growing system of strawberry (Fragaria xananassa Duch.) was begun to change by high bed bench cultivation from soil cultivation. The strawberry plant on the high bed bench system is cultivated at 12%
An asterisk (*) following a name indicates the presenting author.

(093) Effects of Anaerobic Soil Disinfestation and Herbicide Application on Tomato Production and Fruit Quality

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Anaerobic soil disinfestation (ASD) is a potential alternative to chemical dependent fumigation for controlling soilborne pests. The promising effect of ASD has been demonstrated in the U.S. recently, but more studies are needed to optimize site-specific application of ASD in tomato production. A field study was conducted to evaluate the response of tomato production and fruit quality to ASD with different rates of carbon and nitrogen sources and use of preemergent herbicide. The field experiment was carried out in Citra, FL during August to December 2015 using a split plot design with four replications. The pre-plant soil treatment was the whole plot factor, and herbicide treatment was the subplot factor. The pre-plant soil treatments included ASD with 6.93 m³·ha⁻¹ of molasses and 11 Mg·ha⁻¹ of composted poultry manure (ASD0.5), ASD with 13.86 m³·ha⁻¹ of molasses and 22 Mg·ha⁻¹ of composted poultry manure (ASD1.0), and Sandea application at a rate of 70 g·ha⁻¹, and no Sandea application control. Determinate tomato ‘Tribute’ was transplanted 3 weeks after the treatment. Destructive sampling at the second fruit harvest showed that both ASD treatments resulted in significantly higher biomass allocation to stem, and significantly lower biomass allocation to fruit compared with CSF. Significantly higher potassium concentration and lower sodium concentration were also observed in leaf, stem and fruit under ASD treatments in contrast to CSF. The ASD treatments did not differ significantly from CSF in total and marketable fruit number and weight, while ASD0.5 led to

(092) A New Insecticide/Acaricide Formulation from Lycopersicon hirsutum f. glabratum

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The use of natural products for pest control in crop production has been proposed for sustainable agriculture. Crude extracts from the leaves of the wild tomato, Lycopersicon hirsutum f. glabratum possess a pest-resistance mechanism in their glandular trichomes (plant hairs) and the exudates they produce due to the presence of a mixture of methyl ketones (MKs) that has insecticidal and acaricidal properties. Type IV and VI glandular trichomes on the leaves of PI 134417 grown under greenhouse conditions were counted. Major volatile oils from glandular leaf trichomes were extracted, purified, and quantified using gas chromatography (GC) and mass spectrometry (GC/MS). The main objectives of this investigation were to: 1) monitor seasonal glandular trichomes density on L. hirsutum f. glabratum accession PI 134417 for mass production of MKs and 2) prepare a simplified formulation of MKs for potential use of PI 134417 leaf extracts, which could become a valuable source of natural products, in plant protection against spider mites and cowpea aphids. Type IV and type VI trichomes were greatest (P < 0.05) in September and October (97 and 238 trichomes mm⁻², respectively). Quantification of MKs in emulsified extracts of PI 134417 revealed the dominance of 2-tridecanone (the 13-carbon methyl ketone) compared to other MKs (2-undecanone, 2-dodecanone, and 2-pentadecanone) on the leaf surface. Crude leaf extracts of PI 134417 prepared in water caused 33% and 22% mortality, whereas, water extracts containing 1% Alkamuls (an organic emulsifier) caused 93% and 82% mortality of spider mites and cowpea aphids, respectively, 24 hours after exposure.

Specified Source(s) of Funding: Rural Development Administra-

tion of Republic of Korea (PJ011264)
significantly higher number and weight of extra-large size fruit compared with CSF and ASD1.0. Significantly higher number and weight of cull fruit were observed under ASD1.0 treatment in contrast to CSF and ASD0.5. Sandea application had no effect on total or marketable fruit number and weight. Tomato fruit of the ASD treatments had significantly higher titratable acidity and lower sugar/acid ratio compared with CSF, while Sandea had no effect on fruit quality measurements including color, firmness, pH, soluble solids content, titratable acidity, and sugar/acid ratio. ASD treatments showed no difference from CSF on weed control, but Sandea significantly suppressed the growth of nutsedge both on plastic and in planting holes. Considering reducing costs of ASD, ASD0.5 with lower composted poultry manure and molasses application rates may be a better option than ASD1.0 for CSF alternative.

(094) Effect of Sodium Hypochlorite as a Disease Control Against Violet Root Rot Caused by *Helicobasidium mompa* on Apple Trees

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This study was performed to control disease, enhance vigor through rhizospheric rooting and then recover tree growth using sodium hypochlorite (NaClO) against violet root rot disease on apple trees in Chungbuk province. From the experimental results in a field that drenched NaClO according to concentration on an apple cultivar ‘Sansa’ seriously infected to violet root rot, 0.5% NaClO treatment showed significant difference at the range of both 5~10 cm and above 30 cm for shoot length and induction of rooting on root stock in subsoil. Also, 0.25% and 0.5% NaClO treatments improved 51.4% and 58.4% for relative crown density that based on the number of leaves and average leaf area, respectively. Moreover, the two treatments were different significantly on both fruit weight and total soluble solid from the analysis for fruit characteristics as well as much about 2 times from the analysis of starch content for fruiting shoots. In conclusion, our results suggest that one time drenching to 10L per a tree of 0.25~0.5% NaClO in mid-May could be effective to control the violet root rot caused by *H. mompa* and also, improve the vigor recovery with rooting on rhizosphere on apple trees.

(095) Variation Among Muskmelon Cultivars in Attractiveness to Striped Cucumber Beetle and Severity of Bacterial Wilt

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Muskmelon (*Cucumis melo* L.) is one of the most important vegetable crops in the United States. Bacterial wilt of cucurbits, which is caused by *Erwinia tracheiphila* and vectored by striped cucumber beetle (*Acalyymma vitatum* F.), is one of the most serious diseases of muskmelon that influences quality and yield. Many cultivars of muskmelon are grown around the United States, especially in the Midwest. Muskmelon cultivars differ in attractiveness to the striped cucumber beetle (SCB) and susceptibility to bacterial wilt (BW), and no cultivar resistant to BW has been introduced. We conducted field studies in 2015 with 10 to 11 cultivars at three locations in Indiana to identify those most and least attractive to SCB and susceptible to BW. Replicated plots of each cultivar were grown and natural populations of SCB allowed to feed. At one location, additional plots of each cultivar were populated with 5 SCB per plant, and row covers applied to keep the SCB near the plants for 3 weeks. Results differed among locations. Without row covers, cultivars Diplomat and RML 9818 attracted higher numbers of SCBs than most other cultivars at one location each. ‘Dream Dew’ (at all locations) and ‘RML 9818’ (at two locations) had significantly higher percentages of BW than the least susceptible cultivars. Without row covers, ‘Superstar’, ‘Aphrodite’ and ‘Wrangler’ produced significantly greater yield than the least susceptible cultivars. With row covers, ‘Dream Dew’ and least in ‘Superstar’ with other cultivars intermediate. With row covers, ‘Athena’ and ‘Superstar’ produced greater yield than many other cultivars. Experiments will be continued in Summer 2016.

(096) Pesticide-free Rhizosphere Protection-Bug Bags

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The use of a bag to enclose containers or rockwool blocks effectively blocks aphid and fungus gnats from inhabiting plant
roots. An old approach with some new twists, this provides pesticide-free protection from root- media-dwelling pests in soiless, organic, and hydroponic cultivation schemes and could be useful to anyone wishing to reduce the risk of both pests and pesticides at the same time.

Specified Source(s) of Funding: Otoke Horticulture, LLC

**Poster Session—Marketing and Economics**

**(034) Developing Customizable Decision Support Tool for Comparative Economics Analysis of Grafted and Non-grafted Tomato Production**

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Tomato grafting has been utilized worldwide with a long history and grower adoption of grafted tomato production is increasing in the United States. Combing desirable traits of rootstock and scion plants is important for successful use of grafted plants. Usually the rootstock is selected for improved soilborne disease resistance, nutrient uptake, plant vigor, and fruit yield, while the scion is selected for good foliar resistance package and preferred fruit characteristics. Grafting involves additional investment that will increase the cost of production. But at the same time, grafting often results in higher yield, which means higher income for growers. Although some previous studies have shown that using grafted tomato plants could increase net return, the adoption rate of tomato grafting is still low especially for open field production. The major concern is whether grafted tomato production can earn reliable higher income to cover the increased production costs. Almost all the previous economic analyses of tomato grafting are based on specific on- station or farm trials. For most growers such information cannot provide sufficient justification for their adoption of grafting because the production conditions can vary substantially from farm to farm. Growers need to assess the economic viability of tomato grafting based on their own unique production conditions. The objective of this research is to develop a customizable decision support tool to compare economics analysis of grafted and non-grafted tomato production. This tool allows growers to change the quantity and price of the production input items as well as the output quantity and prices based on their own historical data, therefore, to create a scenario that helps them better forecast the cost and benefit of using grafted tomato plants at their farms. The tool can be effective in assisting producers with making both short- and long-term production decisions. The Tomato Budget Tool is a Microsoft Excel template programmed with visual basic application (VBA) that calculates costs and expected net returns of grafted and non-grafted tomato production in open field. The tool can produce graphs and charts to show the comparison result. In addition, break-even and sensitivity analyses are included in the tool, which can help growers evaluate the economic cost and benefit of grafting under different scenarios based on the changes with various input factors (e.g., transplant and labor costs) and output factors (e.g., tomato yield and price).

**(035) Agricultural and Economic Importance of the Main Fruits and Vegetables Produced in Mexico**

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Mexico is one of the five countries with the highest biodiversity, additionally there are climatic conditions for the growth of various products including those of the horticultural sector. The aim of this study was to analyze the available public information about the importance of this sector in Mexico, the highlights are the following facts: In 2014, the main fruits and vegetables in terms of harvested area (in thousands ha) were: orange (321.68), mango (175.77), lemon (154.80), avocado, (153.77), and banana (74.58), as well as chili pepper (143.47), potato (61.41), tomato (50.95), onion (47.43), and tomatillo (44.24). The most important fruits and vegetables by annual production volume (millions t) were: orange (4.53), lemon (2.19), banana (2.15), avocado (1.52), mango (1.45), and papaya (0.84), as well as tomato (2.87), chili pepper (2.73), potato (1.76), onion (1.36), watermelon (0.94), and nopalito (0.82). The annual production value (billions $USD), the most important fruits and vegetables were: avocado (1.56), lemon (0.68), orange (0.51), banana (0.47), strawberry (0.41), blackberry (0.38), and mango (0.36), as well as chili pepper (1.35), tomato (1.18), potato (0.90), asparagus (0.44), and onion, (0.43). The most exported fruits and vegetables (thousands t) were: avocado (512.13), lemon (453), mango (273), and papaya (115), as well as tomato (1500), chili pepper (900), cucumber (497), onion (380), and asparagus (120). The most important fruits and vegetables by annual export volume (millions $USD) were: avocado (1269), lemon (286), pecan (259), walnut (230), mango (150), banana (8), and orange (____), as well as tomato (1158.3), broccoli (350.2), chili pepper (287.9), onion (196.9), asparagus (144.2), and lettuce (133.6). In conclusion, the Mexican horticultural sector is very important, but the order of importance of each fruit and vegetable varies according to the indicator. Orange stood out for harvested area and production volume, while chili pepper was highlighted by harvested area and production value. Avocado was the most important fruit in terms of value of production and exports (volume and value), while tomato was the most important...
vegetable in terms of annual production volume and exports (volume and value).

(036) Economic Analysis of Anaerobic Soil Disinfestation on Tomato Production in Southwest and North Florida
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Chemical soil fumigants (CSF) are widely used for soil disinfestation in horticultural crop production. With the phase-out of methyl bromide due to its impact on ozone depletion, research has focused on developing alternative chemical and biological fumigation methods. Anaerobic soil disinfestation (ASD) is a biological method developed to suppress plant parasitic nematodes, weeds and soil borne pathogens. ASD uses a labile organic carbon source like molasses or composed poultry litter (CPL), to stimulate microbial respiration and O2 consumption in the soil. ASD uses VIF (virtually impermeable film) to seal the soil, thereby limiting gas exchange between soil and air space. ASD uses irrigation to saturate the pore space, which creates anaerobic conditions and enhances the diffusion of byproducts through the soil solution. ASD is environmentally friendly and could result in higher crop than chemical fumigation methods. However its application requires additional labor and increases material costs compared to chemical treatment. This study evaluates the economic viability of using ASD in tomato production drawing on data produced by two field experiments conducted at the University of Florida Southwest Florida REC (SWFREC) in Immokalee and the Plant Science Research and Education Unit (PSREU) in Citra, FL, in Fall 2015. Each location had one CSF and two ASD treatments in a randomized complete block design. The CSF treatment used Pic-Clor 60 at the rate of 224 kg/ha at both locations. The two ASD treatments used different rates of molasses and CPL. 6.93 m³/ha molasses and 11 Mg/ha CPL were applied for ASD0.5, 13.86 m³/ha molasses and 22 Mg/ha CPL were applied for ASD1.0. The economic analysis focused on differences between the CSF and ASD treatments with regard to land preparation cost, gross return and net return. The land preparation cost per plant was $0.35 to $0.38 in CSF and $0.74 to $1.31 in ASD treatments. Two ASD treatments in Immokalee generated higher net return than the CSF treatment. Although the commercial viability on ASD in Citra was not obvious, we can still get profit if we sell the Citra’s tomato at Immokalee’s price. The planting date was not the most concerned factor. However the market tomato price changed a lot as time changing. In conclusion, ASD increased yields and can be an economically viable tomato field production method in Florida in most cases.

(037) The Center for Rural Enterprise Engagement: Helping Green Industry Businesses Navigate New Media Marketing
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The Center for Rural Enterprise Engagement (CREE) was established at Kansas State University in February 2015 after a need was identified for independently owned rural businesses to learn how to capitalize on new online media technologies in order to advance their business goals. Our research team had been working together for two years prior to this, specializing in the nursery and garden center industries. The mission of CREE is to be a Center that focuses on helping small businesses succeed through new-media marketing research. As a generator and source of knowledge about new-media technologies, CREE enables rural businesses to flourish in an ever-changing environment. Our goal is to make research-based knowledge discoverable and accessible to individuals, businesses, and communities and foster positive changes to rural livelihood. Specifically, CREE Objectives are: 1) To generate research-based knowledge related to new media technologies and rural enterprises; 2) To offer hands-on research experiences for graduate and undergraduate students; and 3) To serve as a source for research-based knowledge for local, regional, and national rural enterprises and others involved in improving rural life. Target Audiences for CREE include: 1) Independently-owned rural-based businesses like rural garden centers and retail stores; 2) Farmers and ranchers and other farm-based enterprises such as agritourism; 3) Next generation of agricultural marketing professionals (undergraduate and graduate students); 4) Those involved in rural-economic development in the private and public sectors including Extension personnel; and 5) Other researchers involved in marketing and rural development. From a national perspective, no other Centers or groups of faculty are specifically working on assisting green industry businesses as they seek to improve their social media marketing efforts. Our focus is unique and we have attracted...
attention not only from stakeholders in Kansas, but across the U.S. including businesses in rural and metro areas. It is our goal not only to fulfill our mission of helping these businesses, but to become a thought- and resource leader on this topic. To that end our learning resource, RuralEngagement.org, and social media channels have been influential in reaching our stakeholders. While subject matter discussed is currently focused on garden centers and nurseries, many agribusinesses will benefit from content generated by CREE.

(038) Profitability of Eastern Broccoli Is Highly Dependent on Plant Population

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Eastern broccoli production can have a high profit, but only if produced efficiently. Three populations were tested: 26,000, 39,000, and 52,000/acre in each of four years. The harvest criterion was a crown cut (4.5 to 5.25 inches diameter). The growing conditions were resource-rich in each year to achieve top yields. However in two years, weather disasters limited production. This natural phenomenon allows a risk analysis of the different populations. That is, does the higher investment in a population that is good when everything works, end up causing greater losses if there is a partial crop failure? These results showed that the optimal broccoli population resulted in higher profit, and a reduced risk of economic loss in the event of a weather disaster. The revenue ranged from $5,000 to $13,000 per acre. The net profit ranged from $2,000 to +$4,000/acre. Nevertheless, the same population (39,000/acre) was optimal in each year and never showed a loss. This population is considerably higher than what is conventionally used (15,000 to 20,000/acre). The conventional population is predicted to lose money. Identifying the optimal population for a particular farm is critical for making broccoli a lucrative crop.

(039) The E-Commerce Landscape: An Environmental Scan of Online Greenhouse Retailing

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In the United States, many businesses have moved into the e-commerce sector. Garden centers are among the types of businesses selling through websites and offering products online. An increasing number of agribusinesses are looking to the Internet as a marketing, management, service, and coordination tool. The purpose of this study was to determine how many garden centers were involved in online retailing of plant products. The objectives of this study were to determine if e-commerce was being used by garden centers and describe the techniques implemented. This study was conducted by web-based searches through Amazon.com and each garden center’s website. A sample of 500 garden centers and nurseries was obtained from a national membership list. Preliminary data encompassed a sample of 99 garden centers (20%) using a quantitative content analysis with three coders in Spring 2016. Reliability between coders was obtained for all 15 variables. Data were analyzed in SPSS. Data indicated only one percent (n = 1) of businesses on the list were currently selling live plants on Amazon.com. The business selling on Amazon.com had a single product with a single photo, which was of good quality. The product cost $5 to ship, took 11 days to arrive, and had a description of five sentences. This business had an average customer review of five stars with two reviews. It did not offer a warranty, did not have a discount or loyalty program, or return policy. The company did not list further online resources or include suggested care for the product listed on the sales page. Further results showed that 10.1% (n = 10) of the businesses evaluated sold products online with their own full e-commerce site, while 4% (n = 4) included a downloadable form for customers to complete and mail to the business in order to purchase products. Of the 99 businesses, 84.9% (n = 85) were not selling products online through Amazon.com or a business website. In conclusion, as the e-commerce sector continues to grow, there will be a need for more businesses to sell products online. Garden centers are not strongly concentrated on Amazon.com nor selling online, however the future for online selling shows potential. Many garden centers are not considering national markets, but solely focused on local selling. It is recommended that training be developed to help garden centers navigate selling online. Future research should identify barriers and benefits to garden centers selling online.

(040) Consumer Preference for Sustainable and Organic Processed Vegetables

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Many studies have focused on consumer preferences for fresh organic produce. Yet the studies on consumer preferences for processed organic processed produce are lacking. We conducted online choice experiments with 1062 U.S. consumers to investigate their preferences and willingness to pay for organic, sustainable, and local canned sweet corn. We found compared to conventionally grown canned sweet corn, consumers are willing to pay premium prices for organic and sustainable canned sweet corn. The USDA organic certification and being local also
generates price premiums. We found consumers’ demographics and Body Mass Index affect their preferences and willingness to pay for these attributes.

(041) Consumers of Texas Alternative Agriculture: A Brief Study of Preferences and Beliefs

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In recent years, consumers have become increasingly concerned about how food is produced that parallels the increase of smaller farms with particular production methods, which is termed alternative production. The survey presented questions about preferences on aspects of alternative and conventional agricultural products in an attempt to better understand the Texas consumer and trends in demand of such products. The objectives were to determine how consumer beliefs affect purchasing choices and ascertain the viability of substitution of marketing “local” for “organic” marketing in terms of input costs and labor with similar output costs. Data collection was a Google Form based survey directed toward consumers of Texas agricultural products that was sent to approximately 250 individuals via email who had elected to receive such emails and through an email newsletter managed by Texas Department of Agriculture sent to approximately 20,000 Texas residents. Google Forms present the data in aggregate form in a spread sheet without personal identification information. The survey was open from 15 June 2015 through 31 July 2015. Participants tended to be well-educated females between the ages of 26 and 55 with annual household incomes in excess of $50,000. There were differences between consumers that prefer local foods and consumers that prefer organic foods in regards to beliefs about health, safety, sustainability and what is best for the environment, as well as differences in demographics. The definition of ‘local’ was more likely to be within 50 or 150 miles of purchase for those who preferred organic whereas the definition was more likely to be within the state of Texas for those that preferred local. However, there was no difference between these two groups in regards to willingness to pay more for the preferred labeled foods. Both were willing to pay up to $2.39 more per pound for steak, and up to $1.00 more per pound for tomatoes under their preferred label. These results suggest that it would be beneficial to concentrate marketing efforts on the target sector, and that producers wanting to secure the higher sales price held by organic-labelled products without the increased input costs may substitute a local-grown marketing scheme. Results also suggest that consumers are willing and capable of voting with their food dollar for the production methods they prefer.

(042) Producers of Texas Alternative Agriculture: A Brief Study of Beliefs

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In recent years, consumers have become increasingly concerned about how food is produced that parallels the increase of smaller farms with particular production methods, which is termed alternative production. The survey presented questions about aspects of alternative and conventional agricultural production in an attempt to better understand the Texas producer. The objectives of this research were to determine how producer beliefs affect production and marketing choices and what challenges are present regarding marketing. A Google Form based survey directed toward Texas agricultural producers was emailed directly to approximately 250 individuals who have elected to receive such emails and through an email newsletter managed by the Texas Department of Agriculture which is sent to approximately 20,000 residents. Google Forms present the data in aggregate form in a spreadsheet without personal identification information. The survey was open from 5 Nov. 2015 through 8 Feb. 2016. The majority of the producers who participated in this survey were those that either currently employed alternative production methods, or those who were interested in switching to alternative in the future. The participants were concentrated in central Texas but spread into north, south, east, and panhandle Texas. There were no participants from west Texas. The participants tended to be older, well-educated men and women with smaller agricultural operations which bring in $20,000 in income or less. Beliefs regarding perceived health, safety, environmental health, and sustainability were split approximately 40% local, 40% organic, and 20% other production labels. Operations were 29.8% crop only production, 28.1% livestock only production, and 42% diversified production. Most were interested in eventually adopting labels that indicate production method or who produced it. Evidence suggests that the participants of this survey largely consisted of a vocal group of individuals who were unsatisfied with the products of current agricultural production methods available to them as consumers. This prompted the creation of their own alternative methods with corresponding labels to allow others to vote with their food dollar. These results indicate a need for increased informational resources on production methods, equipment, and marketing routes for producers, particularly those interested in alternative agricultural production.

Specified Source(s) of Funding: USDA NIFA

(043) Texas Alternative Agriculture: A Brief Comparison of the Beliefs of Consumers and Producers

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Specified Source(s) of Funding: USDA NIFA

An asterisk (*) following a name indicates the presenting author.
In recent years, consumers have become increasingly concerned about how food is produced that parallels the increase of smaller farms with particular production methods, which is termed alternative production. There were two surveys that presented questions about aspects of alternative and conventional agricultural production in an attempt to compare producers and consumers. The objectives of this research were to determine 1) how well consumer and producer beliefs about agricultural product labeling align and 2) what, if anything, should be attempted to align any differences in beliefs between the two groups. There were two surveys used in this research which were collected through a Google Form based survey which were emailed directly to approximately 250 individuals who have elected to receive such emails and through an email newsletter managed by the Texas Department of Agriculture that is sent to approximately 20,000 Texas residents. Google Forms present the data in aggregate form in a spreadsheet without personal identification information. The survey that was directed toward Texas agricultural consumers was open from 15 June 2015 through 31 July 2015; the survey directed toward Texas agricultural producers was open from 5 Nov. 2015 through 8 Feb. 2016. Consumer survey participants consisted mostly of women whereas the producer survey participants were more evenly split between men and women. Producer participants tended to be older and more highly educated than consumer participants. The beliefs about aspects of alternative agriculture were similar between the two groups of survey participants. However, producer beliefs were more strongly held as evidenced by several survey-parting comments left by producers. Both producer and consumer beliefs did not necessarily reflect results of existing research into the health, safety, environmental health, and sustainability of organic and local production. These results suggest there is a knowledge void, in this instance, within producers and consumers of alternative agriculture.

Specified Source(s) of Funding: USDA-NIFA

(044) Cost-benefit Analysis of DNA Marker Selection in Sweet Cherry Breeding

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Marker-assisted selection allows researchers to more quickly and efficiently select and breed crops with desired traits and genes as compared to conventional breeding techniques. This technology can require costly investments for reagents, machinery, and labor. Molecular marker research on crops with short breeding cycles such as corn, wheat, and potato has revealed a direct relationship between the time saved and cost of the technology. In order to improve understanding of the cost-effectiveness of using markers for crops with long breeding cycles, we conducted a cost-benefit analysis incorporating marker-assisted selection in a sweet cherry breeding program. The annual operational costs of a sweet cherry breeding program were simulated using the simulated breeding models. The itemized costs of production and cost per unit were estimated for each stage of the breeding model and used to compare the costs with and without the use of marker-assisted selection technology. Simulations were conducted using different selection rates at the stage of greenhouse establishment: intense (12.5%), moderate (20%), and mild (25%). Break-even selection rates where the cost-savings with the use of markers equal the additional costs incurred by using markers were determined. The break-even point simulation was then compared to the simulation of a traditional breeding program without marker technologies. The results have important implications for breeding programs that are considering whether to implement marker-assisted breeding technology.

Thursday, August 11, 2016

Poster Session—Citrus Crops

(270) Citropsis gilletiana for Citrus Germplasm Enhancement and Cultivar Development

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African cherry-oranges (Citropsis species) are near Citrus relatives that are a source of novel traits that could be used for improvement of Citrus, but until recently conventional breeding methods have failed. Citropsis sp. are graft compatible with Citrus, but are only marginally sexually compatible (resulting hybrids have been sterile). Somatic hybridization has been useful for making hybrids between Citropsis and Citrus. All Citropsis species are from tropical Africa, and recent publications suggest Africa as the source of the Liberobacter family responsible for Huanglongbing (HLB) disease. Genes for resistance to this disease and possibly other tropical diseases and afflictions may be present in this gene pool, among which C. gilletiana has been documented as exhibiting outstanding resistance to the burrowing nematode Radopholus similis and to Phytophthora. Using biotechnology methods and traditional breeding, hybrids were created between Citrus and Citropsis gilletiana Swingle & M. Kellerm, in an attempt to exploit traits for improving Citrus germplasm. The first sexual hybrid using an intergeneric tetra-

An asterisk (*) following a name indicates the presenting author.
ploid somatic hybrid (Nova mandarin hybrid + C. gilletiana) was made when it flowered for the first time in December 2014, over 20 years since this hybrid was created. This is the first and only documented flowering of an intergeneric Citrus somatic wide hybrid. A single seedling was obtained using ovule rescue techniques, as fruit failed to develop naturally past 30 days. Somatic hybrids were also obtained using W. Murcott mandarin callus and Red Cooper grapefruit callus respectively combined with C. gilletiana leaves. Hybrids have been identified phenotypically and confirmed using flow cytometry and molecular markers.

(271) Impact of Nutrient Applications on Asian Citrus Psyllid Populations and Tree Physiology

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The Citrus Greening Disease otherwise known as Huanglongbing (HLB) has devastated the Florida citrus industry and has emerged as a threat to citrus groves in the Lower Rio Grande Valley (LRGV). The Asian citrus psyllid (Diaphorina citri Kuwayama) is believed to be the main insect vector of citrus greening disease, which was first discovered in Florida in 1998 and was discovered in southern Texas in 2012. In response to this threat, growers and researchers have developed management programs to control the vector in order to control the spread of the disease. While this program has been highly successful, we must still prepare to manage trees infected with HLB. There is evidence that nutritional programs and management strategies are able to maintain tree health and keep infected citrus fields in production. The development of plant disease symptoms and tree responses to pest infestations can be linked to the nutrients that are important for plant growth. Recent field and laboratory experiments conducted at Texas A&M University - Kingsville Citrus Center have shown that applications of different nutrients applied at different rates on citrus trees have the potential to reduce psyllid populations and limit their development. Our current research project is being conducted using applications of recommended rates and high rates of calcium and potassium silicate foliar nutrient sprays. Although not often thought of as an essential nutrient, silica (Si) is a cell structure component and is known to trigger natural defense mechanisms in plants against insects and possibly fungal disease. Calcium (Ca) is an essential macronutrient, it is important in cell wall and membrane structure as well as coordinating cellular responses to environmental stresses. The objectives for this concurrent field and greenhouse trial are to determine the impact of multiple nutrients at variable rates on psyllid development and reproduction, as well as on tree physiology. We hypothesize that higher rates and combinations of calcium and potassium silicate will increase the leaf hardness and therefore limit the ability of psyllids to feed and reproduce.

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(272) Tissue-specific High Expression of TFL1 Correlates with Citrus Juvenility

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Early flowering is a desirable trait for many horticultural crops including citrus, which are woody trees that can have a juvenile phase from several to over 10 years. Research on floral organ development has identified genes critical to the regulation of juvenility/maturity. TFL1 is a negative regulator where disruption of its expression resulted in a shorter vegetative growth phase in Arabidopsis (Shannon and Meeks-Wagner, 1991). A Mutation in the Arabidopsis TFL1 Gene Affects Inflorescence Meristem Development. Plant Cell 3:877-892). In this study, we sequenced TFL1 orthologs in the citrus gene pool from a wide array of species including Citrus reticulata (mandarin), C. grandis (pumello), C. medica (citron), C. micrantha (papeda), C. paradisi (grapefruit), C. sinensis (sweet orange), C. limon (lemon), C. latifolia (Persian lime), Microcitrus australasica and Eremocitrus glauca. This helps to understand the evolution of citrus flowering as influenced by TFL1. The consensus sequences will be used to design gene silencing and editing targets for engineering early flowering citrus. RT-qPCR expression measurements indicated that one-year-old ‘Hamlin’ sweet orange had much higher levels of TFL1 than the mature trees, and this pattern was observed at the shoot apex tissues. On the other hand, mature ‘Hamlin’ trees at the ages of 3, 5 and 15 years did not show differences from each other. Fluctuations in expression of TFL1 and other flowering genes were also studied from January to June in both juvenile and mature Hamlin trees. Specified Source(s) of Funding: Citrus Research Board

Poster Session—Genetics and Germplasm 3

(122) Field Screening of 25 Advanced Rootstock Selections for Peach (Prunus persica L.) Production in Florida

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Peach production in Florida is challenged by the presence of...
nematodes in the sandy soil characteristic of the growing region. Root-knot nematode species i.e. Meloidogyne incognita, M. javanica, M. floridensis, and M. arenaria are particularly problematic, damaging the root system, and limiting the development of peach rootstocks. ‘Nemared,’ ‘Nemaguard,’ and ‘Okinawa’ were initially utilized in the southeast to provide resistance to M. incognita, and M. javanica. Following detection of M. floridensis in the region during the 1960’s, ‘Flordaguard’ was released providing improved resistance to the M. floridensis. Due to the exclusive use of ‘Flordaguard’ in Florida, there is the potential for development of nematode strains that overcome its nematode resistance. In addition the high degree of susceptibility to Botryosphaeria gummosis of ‘Flordaguard,’ it was necessary to reinitiate development of improved rootstocks. A set of advanced rootstock selections with improved horticultural characteristics was developed by the University of Florida Stonefruit Breeding Program. Seeds were collected in Summer 2014 to create 25 open-pollinated seedling families for field trials. A randomized block design was used to screen the material at Gainesville, FL; Fort Pierce, FL. Destructive sampling was used to generate preliminary data alternate seedling trees of each selection. Observations were made for nematode susceptibility, tree vigor, and degree of branching. Preliminary observations were made after 9 months of growth during the spring of 2016. Nematode susceptibility results from Gainesville, FL, where nematode populations are prevalent suggest that a Prunus mume Siebold & Zucc. selection possesses high levels of resistance to root-knot nematodes. Other lines originating from interspecific crosses between ‘Okinawa’ (P. persica L.) x P. kansuensis Rehder, show no significant differences in nematode susceptibility when compared to ‘Flordaguard’ the industry standard at the Gainesville, FL site. Significant differences were detected between families for vigor and branching at the Gainesville, FL, site. Trends for reduced branching, and increased vigor were observed in crosses with ‘Flordaguard’ at both locations. Several lines performed better than ‘Flordaguard’ for nematode resistance, vigor, and reduced branching, and will be advanced in the breeding program.

(126) Evaluation of Sucrose Content in Cowpea Seed

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Cowpea (Vigna unguiculata (L.) Walp) is a worldwide legume crop to provide mineral, protein, oil, starch, soluble sugar and vitamins for human consumption and animal feeding. The content of soluble sugar is an important agronomic trait in cowpea. It does provide energy to human body, but also increases the tasty and mouthfeel of cooking quality. Therefore, this research aimed to evaluate variation of cowpea seed soluble sugar content, study genetic diversity, and develop high soluble sugar content varieties for cowpea breeding program. Spectrophotometer is a traditional method to use to measure seed soluble sugar seeds at lab. A total of 95 cowpea genotypes, including 50 USDA germplasm accessions and 45 advance cowpea breeding lines collected from different location. The seeds of all tested cowpea genotypes were harvested in Fall 2015 at University of Arkansas Research and Extension Station, Fayetteville, and Hope, Arkansas. The results showed that the seed soluble sugar content in tested cowpea genotypes exhibited a wide range from 4.140% to 14.83% with an average of 6.912%, based on the standard cures Y = 0.0039X + 0.0235 (R² = 0.99878). The top five cowpea accessions with highest seed soluble sugar are ‘Ebony’ in Hope (14.828%), PI664524 (10.695%), ‘09-741’ in Fayetteville (9.997%), ‘09-686’ in Fayetteville (9.520%), and ‘09-692’ in Fayetteville (8.655%), which can be used in cowpea breeding program as parents to develop superior new cowpea cultivars with high soluble sugar content.

(127) Association Mapping for Fruit Traits in Capsicum chinense

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Among the five domesticated species of pepper in the genus Capsicum, chinense is recognized as the most pungent fruit. Understanding genetic diversity, population structure, and the level and distribution of linkage disequilibrium (LD) is of great importance and a prerequisite for association mapping. Association mapping has become one of the most important tools in understanding the dynamics of the domestication processes as well as identification of important genes and genomic areas that are the targets for selection. Data is recorded for fruit traits viz. fruit weight, pedicel length, fruit length, fruit-width and pericarp thickness as well as capsaiacin and dihydrocapsaicin content in Capsicum chinense for association mapping to identify markers also referred to as QTLs (Quantitative trait loci). This study is an attempt to understand the genetic diversity and relatedness of Capsicum chinense using 126 mapped SSR (Simple Sequence Repeats) loci and 250 germplasm accessions of C. chinense.
belonging to various countries representing a wide geographical area. In this study, molecular-genetic diversity is estimated by genetic diversity and heterozygosity (h), $F_{st}$ and $F_{yr}$ are estimated by Wright’s F-statistics. Analysis of gene flow (Nm) based on the private allele method is estimated with Genepop 4. We resolved the population structure of Capsicum chinense using genome-wide SSRs in to 4 clusters. This analysis will be of use for future association-mapping studies to identify markers for various complex traits in C. chinense.

Specified Source(s) of Funding: NIFA

(128) Germplasm Collection of Malus sieversii from Central Asia Is Well-preserved in the USDA-ARS National Plant Germplasm System

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Malus sieversii is the primary wild progenitor of cultivated apples and has many desirable traits and genes for future improvement of apple cultivars. Herb Aldwinckle, Phil Forsline, and others collected M. sieversii germplasm from Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan in their 1989, 1993, 1995, and 1996 explorations. Majority of the materials were collected in the form of open-pollinated seeds. Forty-four “Kazakhstan Elite” budwood were also collected and brought back to the United States through the APHIS quarantine program. Wild Malus germplasm in Central Asia is facing severe degradation resulting from human disturbance of the natural habitat such as firewood gathering and it could be largely eliminated in next 50–150 years. Fortunately, the M. sieversii germplasm from the past explorations has been evaluated and well maintained at the ARS Plant Genetic Resources Unit (PGRU) in Geneva, NY. Seeds of M. sieversii were germinated, planted, and evaluated, and the desirable seedlings were selected on the basis of disease screening, genetic diversity, drought stress resistance, and overall performance at the University of Minnesota, Ohio State University, and PGRU. Seventy-nine, 12, and 263 seedlings, respectively, were selected by these three organizations.

A total of 354 M. sieversii selected seedlings are now permanently preserved at PGRU and their budwood are available for distribution. There are 868 M. sieversii seed accessions with a total of 57,377 seeds stored at a –20 °C freezer at PGRU and most of them are from the explorations. Many of these seed accessions (271) have also been stored as backup at the National Center for Genetic Resources Preservation (NCGRP), USDA-ARS, Fort Collins, CO. In total, there are 288 M. sieversii seed accessions with 40,662 seeds stored at NCGRP. We also had 49,365 seeds collected from controlled crosses among M. sieversii seedlings at PGRU from 2004–06. Furthermore, over 110,000 open pollinated seeds from M. sieversii seedling block (also called the “Botany of Desire Seeds”) were collected from 2002-2015 at PGRU and are available for distribution. Additional M. sieversii seedling evaluation continues at Ohio State University, University of Arkansas, and PGRU. Overall, the germplasm resource of wild M. sieversii from Central Asia is well preserved in the U.S. National Plant Germplasm System.

(129) Characterization of Mineral Nutrients in National Plant Germplasm System (NPGS) Tomato Varieties

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Tomato (Solanum lycopersicum) fruit quality and yield are highly dependent on adequate uptake of nutrients. Potassium, magnesium and calcium are essential elements that influence fruit quality traits such as color, uniformity of ripening, hollow fruit, fruit shape, firmness, and acidity. Sodium is not an essential element for tomato and can detrimentally compete with absorption of potassium and calcium. Daily intakes of potassium, magnesium and calcium in human diets are typically below healthful levels, while sodium intake is often excessive. The objective of this study was to compare 52 diverse commercial varieties of tomato for concentrations of potassium, magnesium, calcium and sodium in fruits. The tomatoes were produced in replicated plots in Geneva, NY in 2010 and 2011. Multiple fruits per plot were harvested vine-ripe, homogenized and assayed for cations. ANOVA showed significant differences among the 52 varieties for all four traits, i.e., cation concentrations ($df = 51, P < 0.0001$ to $0.0034$) and no significant differences between years for any trait ($df = 1, P = 0.3432–0.6770$). Factor analysis showed a strong interrelationship between potassium and magnesium that was independent of calcium and sodium. Potassium and magnesium were highly significantly correlated with each other ($r = 0.64, P < 0.0001$). No other correlations between pairs of traits were observed. Results supported a genetic basis for potassium, magnesium, calcium and sodium concentrations that was consistent across environments. Results will provide insight for development of cultivars with favorable cation profiles in terms of human health and fruit quality.

(131) Evaluating Two Methods for Measuring Cowpea Seed Protein Content

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Cold-hardiness in hybrids and accessions in the University of Georgia (UGA) breeding program in Griffin, GA was assessed following the winters of 2014 and 2015 when mid-winter temperatures were unusually low. Minimum winter temperature in 2014 was −14.2 °C and in 2015 was −12.2 °C. A rating scale of 0 to 5 was used to assess cold damage, with 0 indicating no damage and 5 indicating severe damage. Species was found to have an effect on cold-hardiness (P < 0.0001), with accessions of V. negundo L. var. heterophylla showing the least damage and accessions of V. trifolia L. var. purpurea having the most severe damage. Accessions and hybrids of V. agnus-castus L. sustained an intermediate amount of damage. V. trifolia occurs in Vietnam and other areas of Asia. V. negundo is native to Pakistan, India, and Sri Lanka. V. agnus-castus is indigenous to Southern Europe, the Mediterranean, and Central Asia. No interaction between species and year was found (P = 0.7535). Accessions and hybrids were also assessed to determine if the form of the plant had an effect on cold-hardiness. Replicated accessions were either pruned to tree form or left to grow in a shrub form. Pruning had an effect on some accessions. We will use the insights gained from this study to select accessions as parents in the UGA breeding program to produce Vitex cultivars with increased cold-hardiness.

(132) Cold-hardiness in Accessions and Hybrids of Vitex

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The genus Vitex contains several species that are widely used as ornamentals. Vitex species are distributed throughout tropical and sub-tropical areas ranging from Asia, India, Pakistan, and Sri Lanka to the Mediterranean and Southern Europe. Cold-hardiness in hybrids and accessions in the University of Georgia (UGA) breeding program in Griffin, GA was assessed following the winters of 2014 and 2015 when mid-winter temperatures were unusually low. Minimum winter temperature in 2014 was −14.2 °C and in 2015 was −12.2 °C. A rating scale of 0 to 5 was used to assess cold damage, with 0 indicating no damage and 5 indicating severe damage. Species was found to have an effect on cold-hardiness (P < 0.0001), with accessions of V. negundo L. var. heterophylla showing the least damage and accessions of V. trifolia L. var. purpurea having the most severe damage. Accessions and hybrids of V. agnus-castus L. sustained an intermediate amount of damage. V. trifolia occurs in Vietnam and other areas of Asia. V. negundo is native to Pakistan, India, and Sri Lanka. V. agnus-castus is indigenous to Southern Europe, the Mediterranean, and Central Asia. No interaction between species and year was found (P = 0.7535). Accessions and hybrids were also assessed to determine if the form of the plant had an effect on cold-hardiness. Replicated accessions were either pruned to tree form or left to grow in a shrub form. Pruning had an effect on some accessions. We will use the insights gained from this study to select accessions as parents in the UGA breeding program to produce Vitex cultivars with increased cold-hardiness.

(133) Why Is Pink Lemonade Pink? New Insights into Anthocyanin Biosynthesis in Blueberry

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Anthocyanins are plant pigments with important benefits to human health. They are produced through the flavonoid biosynthetic pathway, and are highly abundant in some fruits and vegetables, blueberries for example. Many breeding programs are interested in improving nutritional quality and in generating ornamental varieties through manipulation of this pathway. In this study, we used a mutant ornamental cultivar of blueberry, ‘Pink Lemonade’, which produces pink fruit, to further our understanding of anthocyanin biosynthesis in blueberry and identify the affected gene in this genotype. Through real-time qPCR experiments, we compared expression of eight structural genes of the flavonoid biosynthesis pathway in ‘Pink Lemonade’ and wild-type genotypes. Significantly lower expression of nearly all the genes suggested that a transcriptional regulator of the pathway was affected. Expression of the transcription factor VvMYB1 (MYB1 of Vaccinium virgatum) was then compared and found to be significantly lower in ‘Pink Lemonade’ than in wild-type. In addition, transient expression assays were per-
formed on ripe fruit of ‘Pink Lemonade’ using cDNA constructs of the VvMYB1 gene from wild-type and ‘Pink Lemonade’, as well as cDNA constructs of two wild-type structural genes of the pathway. Only the construct using the wild-type VvMYB1 gene appeared to partially complement the mutation and result in development of purple fruit. Currently, MYB1-cDNA clones have been isolated and sequenced from ‘Pink Lemonade’ and a wild-type genotype. Genomic clones will be isolated as well and used to identify the mutations in the ‘Pink Lemonade’ MYB1 alleles.

(134) Malus angustifolia (Southern Crab Apple) Exploration in Arkansas, Mississippi, Louisiana, and Alabama
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A sixteen-day and 4947-mile exploration trip was carried out in September 2015 to collect native wild Malus angustifolia (Southern Crab Apple) in Arkansas, Mississippi, Louisiana, and Alabama. Fruit of 37 M. angustifolia trees were collected from 17 locations, 10 trees in Arkansas, 12 trees in Mississippi, 6 trees in Louisiana, and 9 trees in Alabama. Fruit of two muscadine grape (Vitis rotundifolia) were also collected in Arkansas. All fruit of Malus and Vitis were shipped or carried back to Plant Genetic Resource Unit, USDA-ARS at Geneva, NY. Seeds were extracted from all the fruit. A total of 7006 Malus seeds were extracted. The numbers of seed ranged from 2–1362, with an average seed number of 189 per tree. All seeds were processed, accessioned, and stored in the –20 °C freezer at PGRU, Geneva, NY. Understanding the role of the M. angustifolia in the native habitat helps recognizing its morphology in the field, knowing the type of habitat it occupies, and assisting in its identification in the wild. One location in Arkansas and one location in Mississippi have large number of M. angustifolia trees and additional collection effort is needed in the future. Overall, the M. angustifolia germplasm is under threat due to urban development, land use option, extreme weather events, and gene flow from M. domestica.

Specified Source(s) of Funding: The Plant Exchange Office, National Germplasm Resources Laboratory, USDA-ARS

(135) HI7-1: A Promising New Pawpaw Selection in the Kentucky State University Repository Collection
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The North American pawpaw [Asimina triloba (L.) Dunal] is a native tree-fruit that is in the early stages of commercial production with fresh market appeal for farmers markets, community supported agriculture, and organic markets, as well as processing potential for frozen pulp production. Although there are approximately 50 pawpaw cultivars available, many pawpaw varieties tend to be low yielding and have small fruit size of less than 120 grams. Pawpaw varieties with fruit weighing over 120 g per fruit are considered to have a large enough fruit size for commercial sale and processing. New high yielding cultivars with excellent fruit quality would further assist in the development of the pawpaw industry. Kentucky State University serves as the National Clonal Germplasm Repository for Pawpaw. Two goals of the Repository research efforts are germplasm acquisition and evaluation. The repository contains over 2000 accessions from 16 different states; additionally, both open pollinated seedlings from superior genotypes and crosses of superior selections have been incorporated into the repository collection. The selection HI 7-1 was identified in the repository collection with a unique fruit type and promising characteristics as a new potential cultivar. In 2015, the fruit size of Hi7-1 (241 g) was larger than Hi7-5 (181 g), another KSU advanced selection, as well as the industry standard pawpaw cultivar Sunflower (180 g). Hi7-1 has a pleasing orange flesh and large fruit size that would be excellent for processing. This selection, Hi7-1, is being propagated via chip budding onto seedling rootstocks. Yield and fruiting characteristics will be examined in additional trials.

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

Poster Session—Herbs, Spices, and Medicinal Plants

(303) LEDs and Cannabis Growth: A Paradigm Shift Toward Increased Quality and Efficiency of Production
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With the return of Cannabis sp. to legal status in a growing number of states, excessive use of energy for indoor Cannabis cultivation is quickly becoming a threat to several large urban power grids. Most of this energy requirement can be traced directly to the High intensity discharge (HID) lights used as the primary source of light for growth of Cannabis plants. High intensity discharge lamps output a broad spectrum of light including the entire photosynthetically active radiation (PAR) action spectra. While effective as the only source of light for indoor plant growth, HID lamps generate a great deal of heat and emit light outside the PAR action spectrum that may not be used by the plants. Our experimental results show that LED technology has come of age for horticultural applications, and that in addition to being the best choice for lower energy consumption, LumiGrow LED arrays are superior to HID lamps for several aspects of plant
development. The yield of dried Cannabis flowers is comparable for the LumiGrow 650W LED array and a 1000W HID lamp covering the same space, allowing for a savings of almost 50% on electrical consumption. LumiGrow LED arrays also generate less heat, allowing for an overall energy savings of up to 70% for the grower. This decrease in electrical use may eliminate the current problem facing electrical grids. This study also reports LumiGrow LED arrays impart an average increase of 5% in the total THCA content of dried Cannabis flowers compared to plants grown under HPS lamps. The increase in THCA% production by plants under our LED arrays has allowed growers and vendors to effectively compete in their local markets by providing the highest quality Cannabis to the public. Another advantage imparted by LumiGrow LED arrays is the ability to adjust the relative ratio of blue to red light, often referred to as “Spectral Tuning”. These adjustments provide users with the possibility of eliminating some common PGRs from their growth programs. This includes rooting without the rooting hormone IBA, and producing compact plants during flowering without the use of Daminocide or other similar PGRs. These facts alone are of great import and will likely lead to a wholesale paradigm shift away from HID lamps and toward LED lighting for indoor horticulture.

(304) LED Lighting Improves the Yield and Quality of Hydroponically Grown Basil

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The application of light-emitting diode (LED) lighting systems in greenhouse production is rapidly increasing due to improved energy efficiency, increased spectral quality control, and reduction in manufacturing costs. However, research is needed to determine the value of LED lights in comparison to traditional lighting systems. The objective of this study was to determine the impact of LED lighting on greenhouse hydroponic basil (Ocimum basilicum var. ‘Genovese’) production in comparison to traditional lighting systems. Overall biomass accumulation and nutrient uptake were evaluated. Basil was chosen because of its high demand and value among restaurants and professional chefs. Three light treatments were used for this experiment: 1) Natural light supplemented with LED lighting of 20% blue 447 nm/80% red (627 nm) at 100 µmol·m⁻²·s⁻¹, 24 h per day; 2) Natural light supplemented with high pressure sodium (HPS) at 100 µmol·m⁻²·s⁻¹, 24 h per day; and 3) Natural light only (control). The daily light integral (DLI) averaged 9.5 mol·m⁻²·d⁻¹ (ranged from 4 to 18 mol·m⁻²·d⁻¹) during the growth period. The supplemental light treatments each provided 8.64 mol·m⁻²·d⁻¹. Each treatment was grown in 75% relative humidity with day temperatures averaging 29.4 °C and night temperatures averaging 23.8 °C. All treatments were harvested forty-five days after seeding. The LED treatment had the greatest total biomass accumulation, both in fresh (FM) and dry biomass (DM). The LED treatment biomass was approximately 25% greater than HPS, and 208% greater than the natural light control. Biomass partitioning revealed that the LED treatment had more FM and DM for the individual main stem, shoots, and leaves of each plant. The LED treatment had 28% biomass increase over HPS and 55% increase over the natural light treatment. The LED treatment also resulted in greater plant height and main stem diameter, approximately 24% greater than HPS treatment and 45% greater than the natural light treatment. The HPS treatment was not significantly different than the LED treatment for many of the experiment parameters; however, both treatments were significantly greater than the natural light control. Mineral analysis also suggests that both macro and micronutrient accumulation was improved with supplemental lighting. On average, the LED treatment improved macronutrient uptake by 21% over HPS, and 33% over natural light control. The application of LED lighting systems to supplement natural photoperiods may be beneficial for improving overall biomass accumulation, as well as nutrient accumulation in basil.

Specified Source(s) of Funding: University of Tennessee

(305) Chemical Composition of the Essential Oil of a Lavender-flowered Selection of Trailing Lantana

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Lantana montevidensis (synonym Lantana selloviana; Verbenaceae), commonly known as trailing lantana, weeping lantana, and trailing shrubverbena, is a weak-stemmed, trailing shrub from South America with coarsely toothed leaves up to 2.5 cm long and lavender (less often white) flowers in clusters 2.5 cm or more in diameter. Often used as an ornamental groundcover in the landscape and in patio containers, L. montevidensis has escaped cultivation to become naturalized in parts of the southern United States, Australia, New Zealand, Africa, and India. Foliage of L. selloviana is aromatic, releasing essential oils when crushed or brushed against. Essential oils and other phytochemicals produced by plants for defense against insects, bacteria, and fungi may have potential as plant-based biocides and repellents. The chemical composition of the essential oil of a common, nursery-grown, lavender-flowered selection of Lantana montevidensis was investigated in this study. Essential oil was obtained by hydrodistillation of aerial parts for...
3 hours using a Clevenger-type apparatus and analyzed using gas chromatography–flame ionization detector and gas chromatography–mass spectrometry. Lantana montevidensis essential oil was rich in mainly sesquiterpene hydrocarbons, followed by oxygenated sesquiterpenes and monoterpenic hydrocarbons. Further research will investigate the mosquito repellent activity of the essential oil of L. montevidensis.

(306) Current Research Needs Identified By the Cannabis Industry

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Kurt Badertscher
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Informal input was accumulated at the Cannabis Business Summit, National Cannabis Industry Association (NCIA). Attendees were encouraged to identify research for commercial Cannabis production (non-hemp.) While most attendees were from the United States, input also was received from the European Union and Canada. Currently, some states require this crop to be grown only as CEA and must be free of all pesticides, which are more stringent methods than the current USDA Certified Organic growers may use.

Specified Source(s) of Funding: Otoke Horticulture, LLC

(307) Winter Production of Basil (Ocimum basilicum) for Fresh Market and Essential Oil Production

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Essential oils produced from basil are used for culinary applications, aromatherapy, and as a holistic medicine. Our research focuses on growing basil for fresh markets and using unsaleable product for essential oil production. All experiments are conducted during the winter months in a low cost double polyethylene greenhouse. Seeds of eight cultivars were sown in October 2014 and allowed to germinate and grow for five weeks. Multiple plants were then transplanted into 6-inch pots filled with soilless mix. Each pot received one of the 3 fertilizer treatments: either 100 ppm N from 20N–4.4P–16.6K water-soluble fertilizer; 100 ppm N from 20N–4.4P–16.6K plus 6 g of 12N–3.1P–14.9K slow release fertilizer or 100 ppm N from 20N–4.4P–16.6K plus 9 g of 12N–3.1P–14.9K slow release fertilizer. At eight weeks after sowing, plants were pricked out to only 3 per pot and then some were pinched at 15 weeks. Nineteen weeks after sowing, one plant from each pot was harvested, plant parts separated (leaf, steams, and flowering tops), dried, weighed and set aside for essential oil analysis. This procedure was repeated at 24 weeks after sowing. The 100-ppm N from 20N–4.4P–16.6K plus 9 g of 12N–3.1P–14.9K slow release fertilizer treatments produced the plants with the greatest dry mass. Dry plant material was crushed by hand to increase the surface area and then distilled using a 2-L steam distillation apparatus. The 100-ppm N from 20N–4.4P–16.6K water-soluble fertilizers produced the plants with the least dry matter. Stems did not produce any oil. The leaves and flowering tops did produce oil, with the leaves producing higher dry matter to oil ratios. Data will be presented for both harvests as well by treatment. The relationship between oil-bearing anatomical structures and quantity of oil produced will also be presented.

Specified Source(s) of Funding: Nebraska Department of Agriculture Specialty Block Grant Program, NIFA Multistate NE1335, Fleming Foundation Grant and the Agricultural Research Division of the Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

(308) Biomass and Essential Oil Yield and Characterization of 14 Ocimum tenuiflorum Varieties

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The use of medicinal herbs has increased exponentially in recent years as Americans search for natural ways to promote health and prevent disease. Holy basil (Ocimum tenuiflorum) is an important medicinal used to reduce stress, regulate metabolism, and reduce inflammation. In this study, essential oil content and composition of O. tenuiflorum varieties were evaluated for commercial production. We selected 14 holy basil varieties from commercial catalogs and the USDA Germplasm systems. Plants were grown in the field, harvested, and biomass recorded before and after drying. We extracted the essential oils by hydrodistillation. We evaluated the essential oils qualitatively by GC-MS and quantitatively by GC-FID. Varieties were compared and ranked for harvestable yield and essential oil content per plant. The top five yielders included both USDA and commercial varieties, including PI288779, Amrita, PI652059, PI652057, and Kapoor. Major compounds identified in the essential oil included eugenol, Caryophyllene, β-bisabolene, methyl eugenol, estragole, and β-elemene. Eugenol is one of the most desired compounds in the essential oil, and its content varied significantly amongst varieties. Findings suggest an inverse relationship between biomass yield and essential oil content, and different essential oil chemotypes that should all be considered when choosing a variety for commercial production.

Specified Source(s) of Funding: United States Department of Agriculture National Needs Fellowship

An asterisk (*) following a name indicates the presenting author.
The Florida Family Nutrition Program (FNP) is the Supplemental Nutrition Assistance Program Education (SNAP-Ed). In Florida, 3.7 million people received SNAP benefits while an additional 3.3 million people in Florida are estimated to have an income less than 200% of the poverty level. The overall goal of FNP is to reach all family members with a consistent nutrition message of eating for a healthy life. The Farm to School, Farm to Community (F2SC) team supported the programmatic goals of the University of Florida/IFAS Family Nutrition Program (FNP) by proactively expanding FNP’s policy, systems, and environmental (PSE) scopes of work. This is the first year the Florida SNAP-Ed program hired a specialized team, the F2SC team, to implement PSE work. The F2SC team worked integrally with university faculty, school districts, farmers, community partners, and state and federal agencies throughout the state. By the end of the first year, the F2SC team trained 727 teachers, school food purchasers, school food service employees, FNP employees, and farmers on best management practices in 28 direct education training events across the state. Over 100 gardens were installed and maintained with 4,209 beneficiaries (including students and SNAP-eligible community residents) enjoying 80,811 active hours in the gardens. Produce was enjoyed as taste tests, in cafeteria lunches, and taken home to be eating with the family. Over 880 (21%) of the schools in Florida purchased food from Florida farmers as a result of direct action made by the F2SC team. The F2SC team reported direct contact with 858 stakeholders, of which 6% were farmers, and provided service and capacity building to the community. Team members were invited or volunteered to serve on 12 standing food policy, wellness, and food systems committees, worked with 102 individual collaborators and solicited 119 volunteers to provide services valued at $4,942. All PSE work conducted by this team is associated with direct nutrition education provided by FNP program assistants and Extension faculty.

**Specified Source(s) of Funding:** USDA Food and Nutrition Service

**(067) Kale Varieties Grown in Subirrigated Earthboxes**

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The interest in home gardens and growing fresh produce is increasing at a rapid pace. However, urban gardeners with smaller yards are turning to growing vegetables in containers. Self-irrigated containers offer a successful gardening concept for gardeners with limited space such as small yards, porches, or even balconies to grow vegetables. The goal of this project is to test two Kale varieties in subirrigated Earthboxes under varying conditions.

**Specified Source(s) of Funding:** USDA - Florida Specialty Crop Block Grant Program

**An asterisk (*) following a name indicates the presenting author.**
was to evaluate 11 varieties of kale (*Brassica oleracea* var. *sabellica*). The varieties grown were: flat-leaved kale (Premier, Siberian, Beira, Red Russian, and Hanover Salad), curly kale (Starbor, Olympic Red, Vates and Scarlet) and dinosaur kale (Lacinto Dinosaur, Toscano and Black Magic). All were grown in peat-based container media in commercially available sub-irrigated containers called EarthBoxes. Three-week-old seedlings were transplanted on 3 Nov. 2015. A replicate consisted of an EarthBox with six transplants of a single variety and there were four replicates of each variety. We applied a preplant fertilizer consisting of 370 g of 13–13–13 per EarthBox and all were drip irrigated three times a week. On 15 Dec. 2015, 42 days after transplanting, half of the plants growing in each EarthBox were harvested. Data collected consisted of harvest fresh weight, stem width and plant height. The flat-leaved varieties produced greater fresh harvest weights and stem diameters than the curly and dinosaur varieties, which were similar. The plant heights at harvest were all similar except for the curly varieties Starbor and Vates, which were reduced. All the varieties grew extremely well indicating that the concept of producing kale in subirrigated containers is a viable growing solution for urban gardeners with limited space.

**Poster Session—Plant Biotechnology**

**(097) IGT Genes Shape Plant Shoot and Root Architecture**

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The architecture of the shoot and root system influences a plant’s access to sunlight, water, and nutrients and thus plays a critical role in agricultural productivity. Shoot and root architecture is shaped by genetic as well as developmental and environmental factors, and mechanical manipulation. Here we focus on the genetic contribution of a recently discovered IGT gene family, which regulates the orientation of lateral organs. *TILLER ANGLE CONTROL 1 (TAC1)* and *LAZY1* antagonistically affect the trajectory of lateral branches and leaves. Loss of *TAC1* results in upright, narrow tiller and leaf angles in monocots, and narrow branch angles in dicots. In contrast, loss of *LAZY1* leads to wide or prostrate tiller, leaf and branch angles. In roots, a third IGT family member, *DEEP ROOTING 1 (DRO1)*, promotes downward root growth in rice. Here we studied the functions of these three genes in *Arabidopsis thaliana* and *Prunus* species, as well as relationships among them. Expression studies indicated that *TAC1*, *LAZY1*, and *DRO1* were expressed in a tissue specific fashion. *LAZY1* was primarily expressed in shoots, *TAC1* was expressed in both shoots and roots, while *DRO1* was root specific. Despite high levels of root expression, a root phenotype was not observed in *tac1* Arabidopsis mutants, however peach *tac1* mutants have a narrower root system. A *tac1; lazy1* double mutant mimics the *lazy1* mutant in Arabidopsis, suggesting the two genes work in the same pathway. Light exaggerated the *lazy1* phenotype, but surprisingly only the *TAC1* expression was dependent on light. In trees, silencing of *LAZY1* often led to a weeping habit, which increased with age. Loss of *DRO1* in Arabidopsis led to horizontally oriented lateral roots and wide root systems. Collectively, the results show a complex relationship among IGT proteins regulating the branch angles of lateral shoots and roots.

**(098) An Optimized Accelerated Solvent Extraction Method for the Isolation of Health-promoting Compounds from Non-pungent Peppers**

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Peppers are known to contain many health-promoting bioactive compounds. In non-pungent peppers, phenolic acids and flavonoids may positively contribute to antioxidant activity. The present study examined the impact of different accelerated solvent extraction (ASE) conditions on total phenolic content (TPC), and antioxidant activities of non-pungent pepper samples. Direct and sequential extraction was conducted using hexane, ethyl acetate, acetone, methanol, and water at temperatures of 40 °C, 80 °C, 120 °C, 160 °C, and 200 °C under 1500 PSI pressure. The total phenolic content of the extracts was determined by using the Folin–Ciocalteu method and antioxidant activity of the extracts was assayed through radical scavenging activity using 1,1-diphenyl-β-picrylhydrazyl (DPPH) and ORAC assays. TPC was expressed as gallic acid equivalents (GAE) and was found to be highest at 200 °C for all solvents in both the direct and sequential extractions. In direct extraction, MeOH, water, acetone, and EtOAc extracted 13.56, 12.15, 8.62, and 8.44 mg/g GAE, respectively, whereas the sequential extractions had 9.19, 7.50, 5.14 and 4.57 mg/g GAE in MeOH, EtOAc, acetone and water, respectively. A positive correlation between DPPH and TPC was observed with a correlation coefficient ($R^2$) of 0.742.
The data indicated that total phenolics present in MeOH extracts from non-pungent peppers at high temperature likely contribute to overall antioxidant capacity. The optimized ASE method will be more efficient, rapid and reproducible to extract and isolate these compounds from peppers.

**Specified Source(s) of Funding:** This study was supported by United States Department of Agriculture grant Designing Foods for Health through the Vegetable & Fruit Improvement Center 2010-34402-20875 and State funding 2013-121277 VFIC-TX state appropriation.

(099) **Characterization of Ankyrin Gene Family and Other Genes Involved in Pepper Fruit Size and Capsaicin Content**

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Ankyrin repeat (ANK) protein domain is found in a wide range of organisms from plants, humans to the microorganisms. It is a motif that consists of 33-residue which has two alpha helices that are separated by a loop from each other. Our previous GWAS showed that ANK proteins were mapped for fruit size and capsaicin in pepper and the current study aims to investigate it further. Selected Ankyrin repeats will be analyzed using three pepper species (Capsicum annum, C. chinense, and C. baccatum) having variation in fruit size. Current genome mining indicates that there are nearly 110 Ankyrin-repeat genes in pepper. Finally the phylogenetic relationship will be presented using proteins coded by these genes. This research also identified the mutations showing non-synonymous SNPs (single nucleotide polymorphisms) and InDels in ankyrin gene family across three species. Through this investigation, we can track down the evolution of ankyrin gene family in pepper. In addition to that, this study will provide a list of candidates for further improvement of fruit size and capsaicin content in various pepper species.

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

(100) **Orchids on Ice: Protecting Imperiled Floridian Orchids through Cryopreservation**

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Recent advances in cell and tissue culture transformed cryopreservation practices, as the only method of conserving plants’ cellular material viable for long periods of time, from freeze-induced to vitrification and now to encapsulation dehydration, every explant culture can be protected. The methods behind encapsulation dehydration are relatively economical, replacing expensive programmable freezers. This technique has been applied to a wide range of flora species, demonstrating the success, efficiency, and practicality of cryogenically preserving cell suspensions, somatic embryos and meristems. The focus of this study is to evaluate the viability of protocorm-like bodies (PLBs) of critically threatened orchid species (Oncidium ensatum and Bletia purpurea) native to Florida after exposure to long-term cryogenic storage. Optimal encapsulation matrix has been modified previously in the synthetic seed study where 4% sodium alginate with 75 μM of calcium chloride (CaCl₂) and PLBs were encapsulated before applying the pre-culture treatments. Pre-culture treatments, using half strength liquid MS media was agitated over the artificial seeds supplemented with 0.5, 0.75, 1.00, and 1.25 mol, prepared by combining 29.4, 44.1, 58.8 and 73.5 g of sucrose, respectively for an interval of 3 days. Viability of these orchids’ germplasm were validated using tetrazolium chloride (TTC) assays in addition to post-growth stage development following two weeks. Establishing a new cryopreservation protocol for these diverse sub-tropical plants will greatly enhance their ecological survival, increase conservation efforts and supply restoration activities in O. ensatum and B. purpurea. In conclusion, the findings of this research can be utilized as an alternative ex-situ methodology with the potential to direct long-term cryogenic storage of critically imperiled Floridian orchid species.

(101) **Micropropagation and DNA Barcoding Studies in the Genus Scutellaria**

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**Genus Scutellaria**, commonly known as skullcaps, is a member of the Lamiaceae (mint) family of which some of species serve as an excellent source for secondary metabolites or phytochemicals. Increasing the production of medicinally and economically important plant species through micropropagation promotes in
situ conservation by reducing effects of wild cropping, produces an ongoing supply of genetically identical plants, simplifies reproduction of recalcitrant species, promotes conservation of endangered species, and promotes plant improvement through genetic manipulation. Agrobacterium-mediated transformation of selected Scutellaria diversity of short DNA segments. With the DNA extracted from the germplasm collection of 21 species at Fort Valley State University, four candidate DNA barcode genes: the ribosomal RNA maturase gene (matK), the ribulose-1,4-bisphosphate carboxylase/oxygenase gene (rbcL), the chloroplast intergenic spacer (psbA-trnH) and the ribosomal intergenic spacer (ITS) were amplified to discriminate between the Scutellaria species via polymerase chain reaction (PCR). The primers used to ensure proper identification were: rbcL, rbcL2, rbcL1-99, matK2, 1-5-r, matK-3f1, psbA-trnH and ITS2. The amplicons verified by agarose gel electrophoresis were sent for sequencing and DNA sequences were uploaded to the Barcode of Life Data System (BOLD) and Basic Local Alignment Search Tool (BLAST) for analysis.

(102) Characterization of Flowering-associated Genes in Citrus and Applications for Reducing Breeding Time

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Many commercial citrus varieties have a long juvenile period, often taking over 6 years to reach reproductive maturity. This long generation time hinders citrus breeders from quickly developing new varieties with superior genetics. Therefore, early flowering is a desired characteristic for breeding new cultivars and elucidating the molecular mechanisms to efficiently induce early flowering is a useful biotechnology for citrus breeders and producers. However, the factors controlling flowering in citrus are not fully understood. This study focuses on a protein family with a specific phosphatidylyethanolamine binding domain (PEBP domain). This highly conserved gene family is part of an intricate signaling network controlling floral transition and has been well characterized in Arabidopsis thaliana, but has not been fully studied in citrus. In Arabidopsis this gene family has 6 members, FLOWERING LOCUS T (FT), TERMINAL FLOWER1 (TFL1), MOTHER OF FT (MFT), BROTHER OF FT (BFT), ARABIDOPSIS THALIANA CENTRALIS HOMOLOGUE (ATC), and TWIN SISTER OF FT (TSF). Although these genes share homology at the deduced amino acid sequence level, some of these genes repress while others promote flowering. To identify the phylogenetic relatedness between proteins we compared homology of the Arabidopsis proteins with those of Citrus clementina and C. sinensis. This led us to identify 8 PEBP gene family members in C. clementina and 10 in C. sinensis. Phylogenetic trees were constructed to compare relatedness between proteins. Additionally, we identified early and late flowering lines from a segregating F2 mapping population derived from crosses between ‘Pineapple’ Sweet Orange (C. sinensis) and Eremocitrus glauca. To understand the interplay between the different flowering genes in citrus, we used quantitative RT-PCR to analyze transcript levels of flowering-associated genes and determined which of the genes coding PEBPs are differentially expressed in the leaves of early and late flowering individuals. Data from this study will be utilized to identify candidates for artificial manipulation of gene expression and induce early flowering in citrus with the overall goal of reducing breeding time.

Specified Source(s) of Funding: Citrus Research Board

(103) Retrotransposon-based Molecular Markers in Chokecherry (Prunus virginiana L.) and Their Transferability in Rosaceae Family

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Retrotransposons are the largest group of transposable elements (TEs) that are ubiquitous and well dispersed in plant genomes. Retrotransposons can be classified into two groups by the presence or absence of long terminal repeats (LTR): LTR retrotransposons and non-LTR retrotransposons. Transposition/insertion of TEs on chromosomes often generates unique repeat junctions (RJs) between TEs and their flanking sequences. Long terminal repeats are well conserved and abundant in plant genomes, which make LTR retrotransposons valuable for development of TE junction-based markers. In this study, LTR-retrotransposons and their RJs were detected from chokecherry genome sequences generated by Roche 454 sequencing. A total of 1246 LTR-retrotransposons were identified and 338 polymerase chain reaction (PCR) primer pairs were designed. Of which, 336 were used to amplify DNA from chokecherry and other rosaceous species. An average of 283 of 336 (84.2%) LTR primers effectively amplified DNA from chokecherries. A few chokecherry LTR primers also produced amplification in other Prunus or rosaceous species. The majority of the primers (> 75%) produced a single band in chokecherries and other tested species. A total of 78 of 336 (23.2%) primers

An asterisk (*) following a name indicates the presenting author.
amplified polymorphic bands in eight chokecherry lines. Our results suggest that using random genome sequence data to identify LTR retrotransposon markers appears to be rapid and cost-efficient. Development of LTR-based markers in chokecherry could facilitate genetic research in chokecherry and other rosaceous species.

(104) Improvement of Drought Resistance through Manipulation of the Gibberellic Acid Pathway
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Drought is a severe issue facing agriculture due to global climate change and the lack of rainfall in some areas. In recent years, nearly the entire state of California experienced extremely dry conditions, which greatly impacted on crop productions. Therefore, increasing plants’ ability to survive under drought is of great importance to agricultural industry including horticulture. Plant hormone Gibberellic acid (GA) mediates diverse aspects of plant growth and development including seed germination, stem elongation, leaf expansion, and flower and seed development. An Arabidopsis gibberellin acid insensitive mutant (gai-1) has been shown to reduce plant height and alter GA response, resulting in an undesirable dwarf phenotype but enhanced drought resistance. Overexpression of the gai using the 35S promoter would result in strong drought resistant, but completely dwarf plants. To overcome these adverse effects, we propose to use inducible promoters to drive the expression of the gai-1 gene. This strategy will allow us to initiate expression of the gai-1 at specific times or under water stress conditions. We hypothesize that temperately cell rest caused by over-expression of the gai-1 gene would lead to better drought resistance and improve crop productivity without an undesirable dwarf phenotype. We have generated eleven transgenic plants in which the gai-1 gene was over-expressed under a stress-inducible promoter. These plants were subjected to drought treatment and initial characterizations are under way.

(105) Identification of the Pathogen of Powdery Mildew Disease on Dandelions
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Powdery mildew diseases are widespread and the group of causal pathogens has a broad host range. Many powdery mildew diseases are caused by pathogens in the Erysiphaceae, which consists of 16 genera and approximately 650 species. Powdery mildew was observed on common dandelion (Taraxacum officinale), collected in Fayetteville, AR, and was identified using morphology and ITS DNA sequences. Chasmothecia were observed on the leaf surface and were subglobose, 30–35 μm in diameter, and scattered in patches. Asci were oblong, 12–16 μm long, 8–10 μm wide, and enclosed in chasmothecia with ascospores inside. For sequence analysis, three primers were used: 1) the primer ITS1/4 amplifying 563 bp DNA fragment including partial 18S ribosomal RNA gene and complete sequence of ITS1 the 5.8 S ribosomal RNA gene, ITS2, and partial sequence of the 28 S ribosomal RNA gene; 2) the powdery mildew specific primer PMITS1/2 amplifying 696 bp DNA fragment including full sequence of 563 bp DNA fragment amplified by ITS1/4; and 3) the primer ctw13/tw14 amplifying 280 bp DNA fragment including partial sequence of 28 S ribosomal RNA. The sequences were blasted in GenBank. All three sequences from dandelion powdery mildew had 100% similarity to Podosphaera erigerontis-canadensis (GenBank: AB525916), which was identified from dandelion (T. officinale) in Japan. The phylogenetic analysis was performed by using ITS sequences of other powdery mildew fungi from different plants.

(106) Association Analysis of Resistance to Verticillium Wilt in Spinach
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Verticillium wilt, caused by Verticillium dahliae, is an important disease of spinach (Spinacia oleracea L.) grown for seed production. Furthermore, when the pathogen is introduced into other areas, it will affect other crops because of its seedborne nature. The most economical method of controlling this disease...
in most crops, including spinach, is through the use of genetic resistance. The objective of this research was to conduct molecular association analysis for Verticillium wilt resistance in spinach. A total of 95 USDA spinach accessions were evaluated for resistance to Verticillium wilt in this study. Significant genetic variance of Verticillium wilt disease resistance was observed among the 95 spinach accessions with a wide range of disease severity scores from 0.3 to 3.0 on a scale of 0–4. Eight genotypes (NSL 81328, NSL 92513, PI 169675, PI 174960, PI 176774, PI 179588, PI 204732, and PI 204735) showed a high level of resistance to Verticillium wilt with disease severity scores of 1 or less. Genotyping by sequencing (GBS) was conducted and approximately 0.5 million SNPs were discovered from the 95 spinach genotypes. After filtering, 2878 SNPs were used for genetic diversity and association analysis. Two well-differentiated genetic populations and admixtures were postulated in the spinach panel by STRUCTURE 2.3.4 and MEGA 6. Association analysis for Verticillium wilt resistance was done using single marker regression (SMR), general linear model (GLM), mixed linear model (MLM), compressed mixed linear model (cMLM), and enriched compressed mixed linear model (EcMLM) using QGene, TASSEL, and GAPIT. Seven SNP markers (AYZV02052660_2183, AYZV02064249_10266, AYZV02112284_14543, AYZV02123399_146, AYZV02145765_3277, AYZV02199578_156, and AYZV02278250_41) were identified to be strongly associated with Verticillium wilt resistance where LODs ranged from 2.53 to 4.69 and $R^2$ values from 9.4% to 18.5% for these SNP markers. These markers may be useful tools in molecular spinach breeding to select Verticillium wilt resistance through marker-assisted selection.

(107) Isolation and Determination of Four Phenolic Compounds from Peel of Color-fleshed and White-fleshed Potatoes

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Potatoes were first introduced outside the Andes region four centuries ago, and have become an integral part of much of the world’s food. Potatoes were first introduced into Europe in the 16th century and Korea in the early 19th century. In the nutritional aspects, potatoes contain abundant vitamins and minerals, as well as an assortment of phytochemicals such as carotenoids and natural phenols. Chlorogenic acid constitutes up to 90% of potato natural phenols. Due to the high content of potato functional compounds, it has known that potatoes are effective in the prevention of various human diseases. Recently, color-fleshed potatoes ‘Hong-young’ and ‘Ja-young’ were developed by RDA, and it has reported that they have high content of anthocyanin. Additionally they show higher radical scavenging activity compared to white or yellow fleshed potatoes. It will be expected that the consumption of color-fleshed potatoes gradually increase by pre-peeled potatoes and color potato chips. This study was conducted to enhance the utilization of the peel of color-fleshed potatoes. At first, we isolated four compounds from the organic solvents soluble layer in ethanol extract of peel, and their structures were characterized by spectroscopic methods and by comparing their data to those in the literature. Their structures were characterized to be caffeic acid (1), chlorogenic acid (2), gallic acid (3), and protocatechuic acid (4) for the first time reported from this source. These compounds were already reported ingredients but considered to exhibit a high physiological activity. The quantitative determination on the four compounds in peel of color-fleshed [Hong-young (HY) & Ja-young (JY)] and white-fleshed [Superior (SP)] potatoes samples were measured using HPLC. The concentration of caffeic acid in EtOAc fraction (135.4 μg/g) of SP was higher than in different fractions of HY and JY. The concentration of chlorogenic acid in CHCl3 fraction (299.2 μg/g) of HY was higher than in different fractions of JY and SP. The concentration of gallic acid contents appeared to be highest in BuOH fraction (360.4 μg/g) of JY. The concentration of protocatechuic acid in BuOH fraction (87.1 μg/g) of HY was higher than in different fractions of JY and SP. Overall, color-fleshed potatoes had higher amount of physicochemical properties than ‘Superior’. Therefore, color-fleshed potatoes are expected to be highly valuable items for the development and applications of a functional food. In addition, these results will provide fundamental information for improving sitological value, and breeding of new cultivar.

(108) Identification of the SICBL4-SICIPK24 Calcium Signaling Pathway Involved in Salt Response in Tomato (Solanum lycopersicum L.)

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Soil salinity is one of the major environmental factors that hinder the growth and productivity of tomato. Therefore, it is very important to develop tomato plants tolerant to salt stress.

In Arabidopsis, it is well known that calcineurin B-like protein 4 (CBL4) calcium sensor and its target CBL-interacting protein kinase 24 (CIPK24) are involved in mediating salt response. In this study, we isolated tomato cDNA clones (SjCBL4 and SjCIPK24), which encode a polypeptide very similar to the Arabidopsis CBL4 and CIPK24, respectively. Deduced amino acid sequence analysis revealed that SjCBL4 contain four canonical EF-hand calcium-binding motifs. Our electrophoresis mobility shift assays showed that SjCBL4 protein purified from E.coli via the GST-fusion expression system possesses the ability to bind with Ca\(^{2+}\) in vitro. We also discovered that SjCBL4, like AtCBL4, can interact with the Arabidopsis CIPK24 in a yeast two-hybrid system. Furthermore, we demonstrated that SjCBL4 interacts with SjCIPK24 in vitro and in vivo. Taken together, these findings strongly suggest that SjCBL4 and SjCIPK24 are very likely to be the tomato orthologs of the Arabidopsis genes, which can be utilized to develop salt tolerant tomato plants.

(109) Editing of Nitrate Reductase Gene Targeted By CRISPR/Cas9 in Petunia Protoplast System

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Target mutagenesis of genes associated with preferred traits has been advancing continuously and precise technique applicable to genome modification of plant has been introduced recently. A CRISPR/Cas9 system has been recently announced as a powerful molecular breeding tool for site directed mutagenesis in higher plants. Here, we report a site-directed mutagenesis of nitrate reductase gene using direct delivery of purified Cas9 protein preassembled with guide RNA produces mutations efficiently in Petunia protoplast system. After protoplasts isolation, washing and enzyme digestion processes, the resuspended protoplasts were transfected with Cas9 protein and sgRNA. Genomic DNA was extracted from transfected protoplasts for T7E1 assay and targeted deep sequencing of the target locus. The RGEN RNPs induced site-specific mutations with maximum 21% at four different sites in the PhNR gene locus from the T7E1 assay. Targeted deep DNA sequencing revealed a mutation rate up to 17.8% with an average mutation rate of 11.5% at the same NR gene of the analyzed protoplast transfectants. Results also showed that the CRISPR/Cas9 system induced insertion or deletion in four out of six specific sites of the NR gene in the genome of Petunia, demonstrating that direct delivery of RGEN RNPs into protoplast cells of Petunia can be used as an efficient tool for site-directed mutagenesis of gene of interest in the plant.

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Poster Session—Plant Nutrient Management

(371) Nitrogen Rates Reduce Phytochemical Content in Peach Fruit

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Subtropical peach (Prunus persica L.) production helps growers to secure a unique market niche with early fruit production, commanding a premium price. This is particularly attractive for growers in Florida, considering the spread of Huanglongbing (citrus greening), which is severely affecting both acreage and economic returns. However, fertilization practices cannot be transferred from an evergreen tree such as citrus to a deciduous system, as with peach. Fertilization practices, particularly for nitrogen must be optimized for growing regions with significant summer rainfall to prevent unwanted leaching, without sacrificing fruit quality. Thus, the objective of this project was to identify key nitrogen rates for ‘TropicBeauty’ and ‘UFSharp’ for optimal fruit growth and quality, particularly flavonoids, phenolic content, anthocyanins, and antioxidant activity. Additionally, the impact of harvest time on phytochemical content was determined for ‘TropicBeauty’. An overall increase in total phenolic content (TPC), total flavonoid content (TFC), total anthocyanin content (ATC), and total antioxidant activity (TAC)
occurred with decreasing nitrogen rates in both cultivars. A stronger genotype*nitrogen treatment interaction was observed in ‘TropicBeauty’ for TPC, TFC, and TAC. Overall, our data suggests nitrogen rate and harvest time plays an important role in harvested fruit attributes and therefore, can be strategically manipulated to satisfy consumer demand.

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(372) Aging of Coir Dust Root Substrate Can Eliminate Its Influence on Vegetable Seedling Growth Suppression As a Result of Reduced Phenolic Compounds

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This research was conducted to characterize the vegetable seedling plug growth suppression caused by non-aged coir dust root substrate and the pattern of remedying the growth suppression after aging treatment. The growth suppression for tomato, pepper and Napa cabbage seedlings 3–4 weeks after sowing on non-aged coir dust was compared with that of the plants grown with aged coir dust. The reduction of polyphenol concentration in the coir dust during the 6 months aging process was also investigated. For aging treatment, coir dust was drenched with water daily inside a plastic covered greenhouse. Plant height, stem diameter and above ground fresh weight of tomato seedlings grown with aged coir dust were 12.1 cm, 2.21 mm, and 0.67 g, respectively, as compared to 8.5 cm, 1.51 mm, and 0.34 g for non-aged coir dust. Plant height, stem diameter, above-ground plant weight of pepper seedlings grown with aged coir dust were 8.3 cm, 1.4 mm, 0.35 g, respectively, compared to 6.5 cm, 1.12 mm, and 0.25 g for non-aged coir dust. The leaf length, number of leaves and above-ground plant weight of Napa cabbage seedlings grown on aged coir dust for 3 weeks were 4.45 cm, 5.2, and 0.94 g, respectively, as compared to 3.75 cm, 4.7, and 0.53 g for seedlings grown with non-aged coir dust. In general, plants grown with non-aged coir dust showed 51% to 71% reduction in fresh weights compared to those grown with aged coir dust. Ethanol extracts of non-aged coir dust contained 38.8 mg/g polyphenol (determined by tannin standard, Folin-Dennis assay), 168.6 mg/g tannin (vanillin assay), and 0.21 mg/g flavonoid (determined by quercetin standard). The concentrations of these phytochemicals started to drop drastically after two weeks of aging, with their final concentrations lower than those obtained from the commercial coir root substrates sold for seedling production when determined after 6 months of aging treatment.

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

(373) Growth Response of Kale ‘Ripbor’ to Different Growing Medium Conditioners

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Kale (*Brassica oleracea* L. subsp. *acephala*) is considered a high-value crop based on its phytochemicals and health benefits. Consumers’ demand for organic and high-value natural foods is increasing due to increasing food safety and environmental concerns. A pot experiment was carried out to determine the response of kale ‘Ripbor’ plants to K-humate (47.5 g/pot), volcanic minerals (100 g/pot) and dry vermicasts (50 g/pot). The control treatment was Pro-mix BX™ potting mix alone. Only the pH of the dry vermicasts was within the acceptable limits for most plant between 5.7–7.5. The relative growth rates of plants grown in the dry vermicasts (192 mg dry weight/day) was significantly 

\[ P < 0.05 \]

the highest as compared to approximately 600 mg dry weight/day for plants grown in either the K-humate or volcanic mineral amended medium. Total plant fresh weight yield did not significantly

\[ P > 0.05 \]

differ among the three treatments. The dry vermicasts significantly 

\[ P < 0.05 \]

reduced leaf and stem mass densities by more than 30% as compared to the mean densities for the other three treatments including the control treatment. Additionally, leaf dry-matter content was increased by 29% in the K humate, volcanic minerals or Pro-mix BX™ as compared to the dry vermicasts. Leaf tissue N and protein contents were 43% higher in plants grown in the dry vermicasts than in the other treatments. The N and protein contents of the control plants were the least. The results suggested that the dry vermicasts provided suitable growing medium conditions, which led to higher growth response of the kale plants as compared to the volcanic minerals and the K-humate treatments.

(374) On-farm Evaluation of Six Commercially Available Biofertilizers on Organic Tomato and Broccoli

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Biofertilizers contain microorganisms that promote plant growth by one or more mechanisms, including increasing nutrient supply and/or availability. Native soil microorganisms clearly play critical roles in crop and soil health, and a growing body of evidence suggests that inoculation with specific microorganisms can dramatically affect plant growth in controlled environments. The purpose of this study was to test the effects of biofertilizers in a variety of production environments involving on-station
and on-farm plots and high and low fertility conditions. Four commercially available inoculants (Azospirillum brasilense, Pseudomonas protegens, Bacillus amyloliquefaciens, and a 29-strain mix) and a control were applied to newly-transplanted tomato seedlings at four Ohio organic farms and a field station at OARDC in Wooster, Ohio, in 2015, followed by assessments of plant growth and measures of fruit yield. Slight increases in early season growth, fruiting, and flowering were observed for some inoculants on several farms. However, these differences did not lead to significant or even numerically consistent yield increases. A second experiment was conducted on broccoli at a farm in Fremont, Ohio in Fall 2015 to test the combined effects of nitrogen fixing inoculants and fertilizers. Four inoculants (Azospirillum brasilense, Azotobacter spp., a 12-strain mix, and a 29-strain mix) and a control were tested in a full factorial design with two organic fertilizers (composted chicken manure, and a mixed fertilizer), and an unfertilized control. Yield was lowest in plots receiving neither fertilizers nor inoculants, highest in the plots receiving fertilizers, and intermediate in plots that were inoculated, but not fertilized. No additive effects of inoculation and fertilization were observed. Both fertilizers significantly (P < 0.05) increased yield compared to the control. When no fertilizer was added, the inoculants increased yield by 12.9% to 64.6%, with the only the best performing biofertilizer resulting in a significant yield increase over the control. Biofertilizers are only a fraction of the cost of organic fertilizers, so their potential return on investment is high. However, their performance is clearly context-dependent, and conditions under which they perform most consistently are not well understood. In this study, no effects of inoculation were observed under high fertility conditions, suggesting that biofertilizers may have the greatest potential in low-input systems.

(375) Yield of *Porophyllum ruderale* Jacq. As a Function of the Concentration of Nutrient Solution

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In 2014, 355 hectares of *Porophyllum ruderale* were harvested. Recently, this leafy vegetable has gained importance due to its nutraceutical properties. However, scarce information is available regarding its mineral nutrition. The objective was to evaluate the effect of four concentrations of the Steiner nutrient solution (1.0, 1.5, 2.0, and 2.5 \( \text{dS} \cdot \text{m}^{-1} \)) on the yield of *P. ruderale*. The experiment was set up in a greenhouse with plastic cover located at 18º58’51’’NL; 99º13’55’’WL and a height of 1866 m; in Cuernavaca, Morelos, Mexico. The substrate was mix BM2 Berger® and 6-inch pots were used. The sowing was done on 25 May 2015. The yield (fresh weight of aerial biomass) 53 days after sowing was evaluated. With 1.5 \( \text{dS} \cdot \text{m}^{-1} \) of Steiner nutrient solution the highest yield per plant (66.4 g) was obtained.

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(376) Influences of Land Use with Different Crops on Soil Fertility and Productivity in the Area Above the Three Gorges Reservoir of China

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Groundwater level rising after the Three-Gorges-Dam built in China may create a potential impact on soil fertility, land productivity and the development of sustainable agriculture in the area above the Three-Gorges-Reservoir (TGR). A comprehensive survey was conducted in 2009 through 3 counties (Zigui, Xingshan, and Badong) to evaluate the soil fertility, land productivity and economic output from different land uses including cereal/vegetable crops, citrus, and tea crop at various altitudes in the agricultural area above the TGR. The results showed that the soil fertility in cereal/vegetable crop fields on average had soil organic matter (SOM) 15.32 g/kg, total nitrogen (TN) 1.11 g/kg, total phosphorus (TP) 0.62 g/kg and total potassium (TK) 17.10 g/kg, respectively; followed by citrus (SOM 12.97 g/kg, TN 1.02 g/kg, TP 0.57 g/kg and TK 19.21 g/kg), and tea crop (SOM 9.44 g/kg, TN 0.70 g/kg, TP 0.57 g/kg and TK 10.04 g/kg). Regarding the productivity, cereal/vegetable crops had a decrease after water filled up in the TGR, especially in Zigui County, but citrus remained a stable increase in these three counties. However, the economic benefit of citrus industry was significantly greater than those of tea and other crops, which stimulated the citrus acreage and remained the economic output increase in all these three counties. The soil fertility was closely related to the elevation and land use. For instance, the land at altitude 600–700 m with citrus growing had SOM 25.47 g/kg, TN 1.42 g/kg, TP 0.50 g/kg and TK 16.4 g/kg; and the land at altitude 700–900 m with cereal/vegetable crops had SOM 15.73 g/kg, TN 1.04 g/kg, TP 0.70 g/kg, and TK 19.54 g/kg. A change from slope to terrace farming helped
improve soil fertility including soil nitrogen and phosphorus, which might be resulted from the reduction of water runoff and soil erosion. A 10-year monitoring result (2005–14) displayed that soil fertility was generally decreasing in this area, which has become a main constraint to the local agricultural production. The degradation in soil fertility without efficient approaches in soil and water reservation can also be a major concern for a sustainable development of agriculture in this area.

*(377)* Winter Cover Crops Increase Mycorrhization and Yield of Subsequent Cash Crops: A Meta-Analysis

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Cover crops are critical tools for soil, weed and nutrient management in organic crop production systems. Similarly, arbuscular mycorrhiza (AM), symbiotic fungi that live in association with the roots of many crops, play an important role in crop phosphorus uptake, water relations and stress tolerance. We conducted a random effects model meta-analysis to determine the influence of cover crops on AM colonization and yield of subsequent cash crops. Eighty-seven studies were extracted from 21 peer-reviewed publications dating to 31 Dec. 2015. Overall, cover crops increased AM colonization of cash crops by 17% and AM spore density by 110%. When cover crops were known to be hosts of AM fungi, cash crop root colonization was increased by 29%. Conversely, monocultures of non-AM fungi host cover crops (all Brassicaceae) reduced the root colonization of subsequent cash crops by 17%. The AM spore density in soils increased by over 400% when cover crops were allelopathic. Interestingly, spore density was also increased when non-allelopathic cover crops were grown, by a factor of 61% when compared to fallow field controls. When cover crops were monocots and dicots-legumes, subsequent cash crops had a 30% and 24% higher root colonization over controls, respectively. Higher yields were associated with cash crops that had higher percentage of root colonization. Mycorrhizal cover crops appear to have a positive impact on the colonization of cash crops that follow. The few studies reporting cash crop colonization as influenced by non-AM cover crop hosts came from only two publications, however. Further investigation into non-AM cover crops is needed to confirm whether their negative influence on cash crop colonization is real and to better characterize consistency of their effect.

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*(378)* Nitrogen Form and Ratio Impact Swiss Chard (Beta vulgaris subsp. cicla) Shoot Tissue Carotenoid and Chlorophyll Concentrations

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Swiss chard (Beta vulgaris subsp. cicla) shoots contain high amounts of carotenoid and chlorophyll pigments and can be enhanced through varying cultural management practices, such as temperature, light, and mineral nutrient levels. The purpose of this study was to determine the effects of N form and ratio on the carotenoid and chlorophyll concentrations in Swiss chard leaf tissue. Seeds of ‘Rhubarb Chard’ and ‘Oriole Orange’ Swiss chard germinated under greenhouse conditions at the University of Tennessee (UT) and Mississippi State University (MSU). Plants were grown at 25 °C/20 °C (day/night) and grown hydroponically in different nitrogen (N) forms and ratios given as ammonium and nitrate N. Plants were analyzed for biomass production, carotenoid and chlorophyll concentrations, and xanthophyll pigment ratios in the shoot tissue. Swiss chard biomass accumulation responded significantly to N form ($P \leq 0.01$), and the interaction of N form and location ($P \leq 0.01$). Carotenoid and chlorophyll concentrations were also significantly affected by N form ($P \leq 0.01$), and the interaction of N form and location ($P \leq 0.01$). Specifically, concentrations of lutein (LUT), β-carotene (BC), neoxanthin (NEO), violaxanthin (VIO), and antheraxanthin (ANTH) increased by 42.0%, 45.1%, 49.0%, 59.3%, and 36.0%, respectively, when decreasing the treatment ratio of NH$_4$-N: NO$_3$-N from 100:0 to 25:75. Similarly, chlorophyll a (Chl a) and chlorophyll b (Chl b) increased 44.9% and 40.9%, respectively. There were significant differences in xanthophyll cycle pigments between the two locations. Higher light intensities at the MSU location may have contributed to lower pigment concentrations in the shoot tissues of Swiss chard. Since N fertility is important to overall health of the plant, it is crucial to understand the influence of managing it in a production system aimed to increase yields and nutritionally important pigmentation in Swiss chard. Thus, the recommendation for increase biomass accumulation and health promoting carotenoid and chlorophyll concentrations in the leaf tissue should consider decreasing NH$_4$-NO$_3$ ratios in a fertility program to 25% NH$_4$-N:75% NO$_3$-N.

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available phosphorus and potassium average 0.88 and 34.5 mg/100g respectively, extractable cations Ca$^{2+}$ and Mg$^{2+}$ 31 and 2.9 meq/100g respectively, with pH$_{H_2O}$ value of 7.9 at the 0–20 cm soil depth. The results revealed that long-term phosphorus application induced zinc deficiency in plants and stunted growth. Applied zinc increased its concentration in leaves from 27.7–29.5 (P60, N60P90K60) to 36.6–38.2 mg·kg$^{-1}$ (P60Zn10, N60P90K60Zn10) at 8–10 leaves stage averaged over three years. These changes were positively reflected on plant growth and development, and maize protein metabolism. Although, there was not a large difference in protein nitrogen concentration in maize leaves at 8–10 leaves stage, combined macro and microelements application increased protein nitrogen accumulation in leaves 112.7–229.1 and in stems 37.6–155.6 mg/plant at physiological maize maturity. There were strong positive correlations between zinc concentration in leaves and yield of maize. Hence, combined application of micro-and macroelements following systematic application of phosphorus fertilizers to carbonate chernosem soil is important to improve maize protein nitrogen content and accumulation on a long term basis in cropping system.

(380) Effects of Application Rate and Timing of Slow-release Fertilizer and Supplemental Potassium on Yield of Greenhouse-grown Ginger

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Ginger (Zingiber officinale) is a high value tropical spice crop with great potential to be grown under greenhouse conditions during any time of the year in temperate climates. Production of ginger under weather-controlled environments using soil-less substrate is also a way to avoid soil born diseases such as bacterial wilt (Ralstonia solanacearum). The proper application of fertilizer is important to obtain a high yield; however, there is no clear guideline on the optimum rate of fertilizers for the production of ginger. Potassium (K) is a major source of nutrition in ginger, and one of the most important limiting factors for ginger production. Main objectives of the studies were to assess proper application rates and timings of base fertilizer (13N:13P:13K) and K supplement to strategically provide fertilizers to ginger in order to achieve greater yield and increase nutrient use efficiency. Ginger rhizomes pieces were planted in 7-gallon containers filled with commercial substrate (Sungro professional growing mix). Four different rates of base fertilizer (112, 168, 200, and 234 g/container in total), were split and applied at three different times: 0, 2.5, and 4.5 months after planting (MAP). We found that the medium level of fertilizer (168 g/container) produced the highest rhizome yield, while higher levels of fertilizer significantly reduced the yield of rhizomes. A follow-up research was conducted to supplement K at three different rates (0, 50, and 100 g/container) and times (0, 2.5 and 4.5 MAP) in addition to the base application of medium rate fertilizer. The application with increasing K rate significantly increased rhizome yield. The highest yield was obtained when K supplement (100 g) was split and applied at 2.5 and 4.5 MAP, however, when applied only once at either time, it had no impact or a negative impact on yield. These results indicate that the application rate and timing of base fertilizer and supplemental K is critical, and a split application of K supplement in combination with the optimum rate of base fertilizer is an effective strategy to maximize the yield of greenhouse-grown ginger.

Poster Session—Plasticulture

(237) Growing Day-neutral Strawberries in High Tunnels to Target Fall Markets in Southern Indiana

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Producing strawberries in the fall has great economical potential for small farmers. While typical June-bearing varieties require short days to initiate flower clusters and only have one peak harvest around June, day-neutral strawberry varieties are insensitive to day-length, and can have multiple harvests throughout the year. High tunnel systems are an effective tool for achieving season extension of several vegetables and fruit. It provides additional heat units and moderate frost protection that make it possible to produce day-neutral strawberries in the fall. The production practices were seldom explored in the USDA Plant Hardiness Zone 6, and there is little information available on day-neutral varieties suitable for high tunnel production. In this study, day-neutral strawberry varieties: Albion, Sweet Ann and San Andrea were evaluated for the potential of fall harvest in a high tunnel in southern Indiana. Strawberry plugs were planted on 27 Aug. 2015. Runners were removed and recorded weekly in the fall. The first bloom dates of ‘Albion’, ‘San Andrea’ and ‘Sweet Ann’ were on 20 Sep., 24 Sep., and 2 Oct., respectively. First harvest dates were on 20 Oct. for ‘Albion’ and ‘San Andrea’, and on 26 Oct. for ‘Sweet Ann’. Strawberries were picked once a week until 4 Jan. 2016. No significant difference on yield was observed among the three varieties (Albion 77.0 g/plant; San Andrea 37.5 g/plant, Sweet Ann 48.3 g/plant), while ‘Albion’ produced more fruit with smaller sizes compare with ‘Sweet Ann’ and ‘San Andresas’. Average fruit weights of ‘Albion’, ‘San Andrea’, and ‘Sweet Ann’ were 17.6 g, 24.8 g and 28.1 g respectively. There was no significant difference in total soluble solid contents among the three varieties, while fresh firmness of ‘Albion’ was significantly lower than those of ‘San Andresas’ and ‘Sweet Ann’. ‘Sweet Ann’ had more runners in the fall compared with ‘San Andresas’ and ‘Albion’, while there was no significance difference in canopy.
sizes among the three varieties. Research conducted in multiple years is warranted to determine influences of environmental factors on the production system. Planting density also needs to be examined to justify the quantity of strawberries that can be produced in the fall season.

(238) Biodegradable Mulch Films: Their Constituents and Suitability for Organic Agriculture
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In October 2014, the National Organic Program (NOP) of the US Department of Agriculture (USDA) added biodegradable biobased mulch film to the list of allowed substances for certified organic production. An allowable mulch film, under the new rule, must 1) be biobased as determined by ASTM D6866; 2) biodegrade at least 90% within two years as determined by ASTM D5988 or ISO 17556, and growers must verify that 90% biodegradation is attained in their field(s); 3) meet compostability standards ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088; and 4) not be produced using organisms or feedstocks already excluded from organic certification standards (e.g., synthetic, GMO). While minor additives are exempt from the biobased requirement, a 2015 memo by the National Organic Standards Board (NOSB) clarified that 100% of the primary feedstock(s) must be biobased. To date, no biodegradable mulch (BDM) has been certified to meet these requirements. Materials scientists have developed several polymers with the physical and chemical characteristics necessary to create a functional mulch film that also biodegrades under favorable conditions. The foundation of these polymers may fall along a spectrum from completely synthetic (e.g. petroleum-based feedstocks) to completely biobased (e.g. starches). And while most polymers may be completely biodegradable in their pure form, some require additives to ensure timely or complete biodegradation. Additionally, most biodegradable polymers require additives to improve their ability to be processed into film (e.g. plasticizers) or to adequately function as mulch (e.g. colorants). To better understand the challenges growers, and certifiers, face in identifying BDM technologies and products appropriate for USDA-certified organic production, this poster presents BDM products available on the market with information about their feedstocks, manufacturing processes, and biodegradability, as well as some of the most common additives used in BDM manufacture. Additionally, we identify those factors limiting products’ suitability for organic production.

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(239) Comparison of Weathering at Two Diverse Geographic Locations and Simulated Weathering on the Physicochemical Properties of Biodegradable Plastic Mulches
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Plastic mulches are an integral component of specialty crop production. Yet, conventional plastic mulches, prepared typically from polyethylene, are problematic due to their poor sustainability. Firstly plastic mulches require labor-intensive retrieval after harvest, and secondly because they are so resilient they have long-term accumulation in the environment. Biodegradable plastic mulches (BDMs) address many of the concerns with using conventional mulches. However, their widespread use by growers is limited by unpredictable and variable performance both during their use and following their incorporation into the soil. This study focuses upon the changes in physicochemical properties of three commercially available plastic mulches marketed as biodegradable: BioAgri, a film prepared from polyesters sometimes blended with starch (BioBag Americas, Inc. Dunedin, FL); Organix, prepared from Ecovio®, a polyester film developed by BASF (Organix Solutions, Maple Grove, MN); and Naturecycle, a proprietary starch-polyester blend (Custom Bioplastics, Burlington, WA). In addition, the study included one experimental mulch prepared from biobased polymers (prepared by Metabolix Inc., Cambridge, MA), and two control mulches [black polyethylene mulch (non-biodegradable control), and WeedGuardPlus, (fully biodegradable control) Sunshine Paper Co., Aurora, CO]. The study was carried out at two diverse geographic sites: Knoxville in eastern Tennessee and Mount Vernon in northwestern Washington. Our findings demonstrate that mechanical properties (tensile strength and percentage of elongation at break) the mulches underwent the greatest extent of change in Knoxville. All three commercially available plastic BDMs underwent a major decrease of tensile strength and elongation, reflecting embrittlement, due to the stronger sunlight and higher temperatures in Knoxville as compared to Mount Vernon. In contrast, conventional PE mulch did not undergo deterioration at either site. Results from simulated weathering demonstrated that tensile strength decreased exponentially with time. The overall results of this study demonstrate that weathering has a major impact on the structural integrity of BDMs during their use in the field. The
extent of weathering also impacts the inherent biodegradability of BDM. Therefore the environmental factors of the location where the BDM is used will influence the biodegradation of the product both during its use and after.

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**Poster Session—Produce Quality, Safety, and Health Properties**

**(195) Compositional Equivalency of Conventional and Organically-grown Sweetpotatoes**

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Sweetpotato root composition was determined in eight commercially important sweetpotato cultivars grown in California under conventional and organic production methods. Analyses of root tissues were made after 6 months of storage at 14 °C. Large differences in percentage of dry matter existed between cultivars, ranging from 33.4% in the roots of ‘Stokes Purple’ to 18.1% in ‘Bellevue’. No significant difference in dry matter content existed between conventional and organically grown sweetpotatoes. The principal sugars in the raw roots of all cultivars included the main disaccharide sucrose, followed by the secondary monosaccharides glucose and fructose. Raw roots of ‘Burgundy’ contained the highest amount of sucrose (6.77%), while ‘O’Henry’ contained the lowest amount (2.50%). ‘Diane’ and ‘Bellevue’ contained the highest amount of glucose (2.62%), while ‘Kotobuki’ contained the lowest amount (0.57%). ‘Bellevue’ contained the highest amount of fructose (1.90%), while ‘Kotobuki’ contained the lowest amount (0.52%). ‘Diane’ contained the highest amount of total sugar (9.94%), while ‘O’Henry’ contained the lowest amount (4.57%). No overall difference in any of the individual sugars or total sugar content existed between conventional and organically grown sweetpotatoes. Crude protein content ranged from 2.71 g/100g fresh weight in ‘Stokes Purple’ to 1.53 g/100g in ‘Bellevue’. No overall difference in crude protein content existed between conventional and organically grown sweetpotatoes. Potassium (K) was the principal macronutrient element in all cultivars and ranged from 384 mg/100g in ‘Bonita’ to 253 mg/100g in ‘Bellevue’. Phosphorus (P) was the second highest macronutrient and ranged from 78 mg/100g in ‘Stokes Purple’ to 35 mg/100g in ‘Bellevue’. The remaining macronutrients were present in lesser amounts, with generally similar levels found in calcium, magnesium, and sulfur. Iron (Fe) was the principal micronutrient found in all sweetpotato cultivars and the content ranged from 0.72 mg/100 g in ‘Kotobuki’ to 0.34 mg/100 g in ‘Bellevue’. Zinc (Zn) and manganese (Mn) were the secondary micronutrients in all cultivars and found in similar concentrations. Boron and copper were the least abundant micronutrients and also present in similar concentrations. ‘Stokes Purple’ was the cultivar that contained the highest amounts of macronutrients and micronutrients, while ‘Bellevue’ was the cultivar that generally contained the lowest amounts. Although substantial differences in nutrient element composition existed between cultivars, there was no overall difference between conventional and organically grown roots in most macronutrient and micronutrient concentrations. However, P, Mn, and Zn contents were higher in conventionally grown roots.

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**(196) Carotenoid Content of Butternut Squash Cultivars Following Harvest and Storage**

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Butternut squash is a high value niche crop usually grown in cooler climates. New cultivars offer adaptation to the humid and warm North Carolina climate. Butternut is high in alpha and beta carotenoids and contributes over 20% of the required daily value of provitamin A in a serving. Twenty-five cultivars grown at three locations from eastern to western NC (USDA climate zones 8 to 5) were harvested at 60, 80, and 120 days after planting, respectively. Twenty five cultivars were evaluated for soluble solids content and carotenoid composition after harvest, and thirteen of these were stored for 0, 5, and 9 weeks at 13 °C, 70% relative humidity. Samples were cut from the center of the squash neck, steam microwaved until tender (about 7 minutes at 900 W), frozen at −20 °C, thawed, and homogenized. Soluble solids content was measured using a digital refractometer. Carotenoids were extracted with hexane and determined using high performance liquid chromatography. Cultivars consistently highest in total carotenoids at harvest were the personal size ‘Honeynut’ and ‘Butterscotch’ (6–9 mg/100 g fresh weight) and the fresh market cultivars ‘Metro’, ‘Bettern900’, ‘Avalon’, ‘Waltham’, ‘Butterly’ and ‘RB4757A’ (6–8 mg/100 g fwt). Soluble solids content ranged from 7 to 11% at week 0 and increased to 7 to 18% at week 9 of storage among cultivars. Total carotenoid and beta carotene content increased on average 50% to 70% between weeks 0 and 9 of storage. These results show that provitamin A content can increase substantially in stored butternut squash and that there is a range of cultivars suited for North Carolina production that are high in provitamin A content.

*Specified Source(s) of Funding:* NCDA Specialty Crops Block Program
**(197) Bioactive Compounds in the Pulp, Jelly, and Popsicle Made from the Amazonian Fruit Camu-Camu**

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The camu-camu [Myrciaria dubia (H.B.K.) McVaugh of the Myrtaceae] is native to the Amazon and is cultivated on a small scale in some Brazilian states. Camu-camu fruits are considered significant sources of different bioactive compounds, especially polyphenols and ascorbic acid. The fruit has been reported to have important functional, biological and nutraceutical effects. The present study was designed to quantify the phenolic compounds and antioxidant activity of the pulp and products developed using camu-camu pulp. The camu-camu fruit used in this study were collected in an area where the trees grew as native vegetation, at the banks of the River Dog, Roraima, Brazil. The fruit pulp was freeze-dried for 24 hours. To obtain the popsicles 1 kg of pulp, 1 kg of sugar and 3 L of water were homogenized in an industrial blender. The following day the popsicles were freeze-dried for 24 hours. After drying, the material was stored in aluminum bags and kept at −20 °C. For jelly confection, 2 kg of pulp, 1.9 kg of sugar and 0.15 g of pectin were mixed and heated to 100 °C for about 1 h until a gelatinous consistency was obtained. The pulp and the products derived were extracted methanol: chloroform: water (12:5:1, v:v:v). Phenolic compounds were evaluated by the Folin-Ciocalteau and the antioxidant activity by FRAP assay. Phenolic compounds have higher values in the pulp, followed by jelly and popsicle, where mean values were 122.0, 24.3 and 8.4 mg gallic acid equivalents/g product, respectively. The antioxidant activity of these materials also showed similar behavior, higher values in the pulp, followed by jelly and popsicle, with mean values of 1.13; 0.63 and 0.22 mg Fe₂SO₄/g product, respectively. Liquid chromatography followed by electrospray mass spectral analysis of the pulp extracts indicated that the presence of several ellagitannins and some that were preserved in the food preparations. Food items especially the jelly prepared from camu-camu pulp makes the benefit of the bioactive compounds to be realized widely, overcoming the high acidity of the fresh fruit.

Specified Source(s) of Funding: EMBRAPA and the University of Roraima

**(198) Regulatory Mold and Yeast Testing Impact on the Cultivation of Cannabis**

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This presentation describes the impact of regulatory testing and filtering of cannabis products with regard to mold and yeast content. This poster describes how one major cannabis producer used air sampling to identify and mitigate fungal and bacterial exposure levels and sources. Also described are the interesting political aspects of cultivation wherein mold and yeast standards set by regulators in Colorado seem incongruent with the picture painted by the Center for Disease Control’s mold and yeast resources. Cultivation practice, testing and radiation processing are included in the discussion.

Specified Source(s) of Funding: Otoke Horticulture, LLC

**(199) Fruit Quality and Volatile Compounds of Seedless Watermelon As Affected By Grafting**

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Interest in watermelon grafting is growing in the United States, however, limited information is available regarding the changes in flavor-related fruit characteristics, particularly volatile compounds of seedless watermelons as a result of grafting. This study was conducted to explore the influence of grafting with interspecific squash rootstock on fruit quality modification including volatile compounds in seedless watermelon. Triploid watermelon ‘Melody’ (Citrullus lanatus) and interspecific squash ‘Super Shintosa’ (Cucurbita maxima × C. moschata) were used as the scion and rootstock, respectively. Both grafted and non-grafted watermelon plants were grown with two different in-row spacings of 0.76 and 1.68 m and a constant between-row spacing of 2.44 m in a split-plot design with four replications during Fall 2015 in Citra, FL. Fully ripe watermelon fruit from the second harvest were sampled for quality evaluations. Rind and flesh firmness of grafted watermelon fruit were significantly higher than that of non-grafted fruit. The wider in-row spacing resulted in reduced flesh firmness. Neither grafting nor plant spacing exhibited any significant impacts on fruit soluble solids content, titratable acidity, pH, flesh color, or lycopene content. Out of the 50 volatile compounds identified from the watermelon tissue using solid-phase microextraction (SPME) with gas chromatography–mass spectrometry (GC-MS), twenty compounds, including alcohols, aldehydes, esters, and terpenes, were compared among the treatments. Amounts of each volatile compound in fruit relative to non-grafted ‘Melody’ at 0.76 m spacing were determined, and comparisons among...
(200) Variation in Mineral Composition Among Species of Brassica Crops
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The Brassica genus is a diverse group of plant species that include popular vegetables such as broccoli, cabbage, and kale, which are excellent sources of various essential minerals. Although considered nutritious vegetables, the mineral composition of Brassica vegetables has only been reported for a few crops. The variation in nine essential minerals was analyzed in commonly consumed portions of 31 total cultivars of 13 different vegetable crops (bok choy, broccoli, Brussels sprouts, cabbage, cauliflower, Chinese broccoli, collard greens, kale, kohlrabi, komatsuna, mustard greens, savoy cabbage, turnip, and turnip greens) from five Brassica species grown in 2012. Additionally, the year-associated environmental effect on mineral concentration was investigated for a subset of selected crop accessions grown in 2012 and regrown in 2013 (14 cultivars of seven different vegetable crops including bok choy, broccoli, cabbage, cauliflower, collard greens, kale, and savoy cabbage). All plants were grown in Urbana, IL, with using commercial agricultural production practices. In the 2012 study, bok choy was the highest in P, Fe, Cu, and Zn. The concentrations of Mg and Na were the highest in kale. Collard greens, mustard greens, and turnip greens contained the highest levels of K, Ca, and Mn, respectively. In the two-year study with selected accessions, the mineral variation between different species was significant for all minerals except for Cu and accounted for 1% to 38% of the total variance. The mineral concentrations significantly differed between two growing seasons, except for macro minerals Ca, K, and Na with year effect accounting for 2% to 57% of the total variance. A significant interaction between species and year was also found for all minerals except for Ca, K, and Na. In this two-year study, bok choy was the highest in K, P, Fe, Zn, and Mn while Na and Cu were the highest in cauliflower. Collard greens and kale contained the highest level of Ca and Mg, respectively. In the two-year study, Ca, Mg, and Mn concentrations were negatively correlated with growing degree days, total evaporation, and total solar radiation and positively correlated with the difference between precipitation and evaporation, indicating that uptake and accumulation of these minerals might be more sensitive to environmental conditions compared to the other minerals analyzed in this study. The result of this study shows the variation in mineral composition in various Brassica crops and will help to develop breeding strategies and fertilization regimes to enhance mineral nutrients concentrations from consumption of these crops.

(201) Epicuticular Wax on Leaves of the Rosette and Inflorescence of Lettuce
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Lettuce is a popular leafy vegetable that can harbor foodborne human-pathogens under conducive production conditions. Recent studies reveal that the epicuticular waxes on lettuce can affect the attachment of foodborne pathogens such as Escherichia coli and Salmonella enterica. However, little is known about what developmental stages in lettuce are most likely to harbor these pathogens, and whether differences in surface waxes during development can effect pathogen attachment. Epicuticular wax chemical composition and contact angles on lettuce leaves were analyzed on immature and mature rosette leaves, and leaves at three different attachment points in the inflorescence stem of lettuce (upper, middle, and lower leaves). Wax composition was similar for both immature and mature rosette leaves as revealed by gas chromatography–mass spectrometry. The total amount of wax on the upper and middle inflorescence leaves was similar, and about two fold higher than for lower leaves, which in turn were five fold higher than rosette leaves. These upper and middle leaves produced significantly higher amounts of long chain alcohols than rosette stage leaves. Specifically, the amount of hexacosanol (C26), the primary wax component, was much higher on upper and middle inflorescence leaves than lower inflorescence leaves, which in turn were much higher than on rosette leaves. Leaf contact angles and epicuticular wax crystal
density (revealed using scanning electron microscopy) were positively correlated with total wax amount. No wax crystals were observed on either immature or mature rosette leaves, whereas lower inflorescence leaves had sparsely distributed wax crystals, and middle and upper inflorescence leaves had a very high density of surface wax crystals. Hexacosanol recrystallized in vitro produced plate-like crystals similar to those found in vivo on lettuce leaves, suggesting a possible role for wax composition in crystal morphology. Whether the heavier wax deposits we observed on upper and middle inflorescences inhibit attachment of dangerous human-pathogens, and whether lettuce waxes might be modified (either genetically or via cultural practices) to reduce the threat of such infections on lettuce is the subject of ongoing studies.

(202) Effect of High CO₂ Level on Growth and Nutritional Quality of Lettuce and Spinach

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The rising atmospheric CO₂ levels, in addition to being an important factor in driving the global climate change, can directly affect plant growth and development including its ability to provide nutritional sustenance to humans. The main objective of this study was to examine the effects of elevated CO₂ level on the growth and nutritional aspects consisting of protein, important minerals and phytochemicals in lettuce (Lactuca sativa, var. Black-Seeded Simpson) and spinach (Spinacia oleracea, var. Bloomsdale Long Standing). Plants were grown in growth chambers at 18 °C/20 °C (night/day) and 280–300 mmol·m⁻²·s⁻¹ PAR with either 400 ppm (control) or 700 ppm (elevated) CO₂. The net photosynthetic activity in lettuce was significantly higher at elevated CO₂ level, however, with no significant differences in spinach between the two CO₂ levels. This was also reflected in an increased biomass accumulation in lettuce at elevated CO₂ but not in spinach. However, in both lettuce and spinach, stomatal conductance and plant total leaf area were drastically reduced at elevated CO₂ level. Significant decrease in protein concentrations, more than 30% in lettuce shoots and 24% in spinach shoots, was noted at elevated CO₂ while carbon accumulation was not affected by higher CO₂ level. Shoots of both species had reduced levels of phosphorus and potassium in response to high CO₂ level. In addition, concentrations of many micronutrients were drastically reduced; sulfur by 37%, manganese by 31%, zinc by 29%, and copper by 21% at elevated CO₂ in lettuce shoots. The results on the total phenolic content and antioxidant capacity in lettuce and spinach shoots were variable with regard to increasing CO₂ level. Significant increase in the total phenolic content and antioxidant capacity was observed at elevated CO₂ in lettuce shoots. The total phenolic content in lettuce shoots increased by more than 2-fold in response to elevated CO₂. However, the elevated CO₂ level did not have any effect either on the total phenolic content or the antioxidant capacity in spinach shoots. The study also characterizes the changes in the accumulation of individual phenolic compounds in lettuce and spinach shoots in response to increasing CO₂ level.

Specified Source(s) of Funding: Partially funded by Kansas Agricultural Experiment Station.

(203) Influence of Cultivar and Growth Stage on Phytochemicals in Pac Choi

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Plant polyphenols are plant secondary metabolites that have been widely researched for their health-promoting properties, which are mostly related to their antioxidant activity. Phenolic compounds, along with ascorbic acid, are recognized for their potent antioxidant activity in the plant response to abiotic stress. As an important group of antioxidant phenolic compounds, anthocyanins are pigments responsible for the red, blue, purple, and orange color of all plants. Pac choi (Brassica rapa var. chinensis) is a popular leafy green produced by many growers in Florida for local markets and the Asian vegetable market. While pac choi is known for green leaves with white or light green petioles, the red pac choi cultivar is also becoming available in most recent years. This study was performed to examine the impacts of cultivar and growth stage on phenolic and ascorbic acid contents in organically produced pac choi. Three pac choi cultivars Joi Choi, Feng Qing Choi, and Red Choi were analyzed for total phenolics, ascorbic acid, and anthocyanins at two weeks after transplanting (baby leaf stage) and four weeks after transplanting (mature leaf stage), respectively. Folin-Ciocalteu method was used to determine the total phenolic content (expressed as mg gallic acid equivalents/g FW), while total monomeric anthocyanin pigment content (expressed as μg cyanidin 3,5-diglucoside equivalents/g FW) was measured using the pH differential method. A randomized complete-block design with three replications was used with duplicate samples for each cultivar at each growth stage. As predicted, ‘Red Choi’ had significantly greater anthocyanin content when compared to ‘Joi Choi’ and ‘Feng Qing Choi’. For total phenolic concentration, ‘Red Choi’ was significantly higher than Feng Qing Choi, which was significantly higher than Joi Choi. Feng Qing Choi and Red Choi had similar levels of ascorbic acid, while both had significantly greater levels than Joi Choi. Interestingly, all 3 cultivars had significantly higher levels of total phenolics and ascorbic acid at the baby leaf stage in comparison with the mature leaf stage, while there was not a significant difference in anthocyanin content between growth stages. Moreover, ‘Feng Qing’ showed greater differences between the growth stages in total phenolic and ascorbic acid concentrations than the other two cultivars. The results demonstrate that levels of polyphenols and ascorbic acid in pac choi can be impacted by not only the varietal difference but also different growth stages of plants.

An asterisk (*) following a name indicates the presenting author.
(204) The Effect of Sowing Date on Plant Growth and Nutritional Value of Cichorium spinosum L. Plants
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Cichorium spinosum L. is a wild edible green, native to the Mediterranean basin, which usually grows in coastal areas and plateaus. In the present study, plant growth and mineral composition of C. spinosum was evaluated for two consecutive growing periods. Seeds of C. spinosum were sown in seed trays on 15 Oct. 2013 and 17 Jan. 2014 and young seedlings were transplanted on 12 Dec. 2013 and 7 Mar. 2014, respectively. Harvest took place at marketable size. Seed germination rate was lower than 50% at both sowing dates (46% and 38%, for first and second sowing, respectively), whereas seedling emergence was complete after 11 and 18 days, for the first and second sowing date, respectively. Leaf fresh and dry weight, and rosette diameter did not differ significantly, whereas number of leaves and total leaf area was higher in the first sowing. Regarding mineral composition, Ca, Mg and Mn content was higher in the second sowing date, whereas K and Na in the first sowing date. The Fe and Zn content were not affected by sowing date. Regarding nutritional value, ash content increased in the second sowing date, whereas protein and carbohydrate content decreased. However, fructose and glucose and consequently total sugars content, and ascorbic acid content increased in the second sowing, whereas α-tocopherol and total tocopherols, and chlorophyll b decreased. Fatty acids consisted mainly of linoleic, α-linolenic and palmitic acids, whereas no significant differences were observed between the two sowing dates. PUFA/SFA and n-6/n-3 ratio was higher than 0.45 and lower than 4.0, for both sowing dates. In conclusion, sowing date affected plant growth in terms of leaf number and leaf area, without affecting leaf fresh weight, whereas second sowing resulted in an increase in sucrose, glucose and total sugars content and ascorbic acid content that could improve the taste and nutritional value of the final product.

(205) Growing Environment Affects the Levels of Health Promoting Compounds in Tomato
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In the present study, plant growth and mineral composition of Cichorium spinosum L. is a wild edible green, native to the Mediterranean basin, which usually grows in coastal areas and plateaus. In the present study, plant growth and mineral composition of C. spinosum was evaluated for two consecutive growing periods. Seeds of C. spinosum were sown in seed trays on 15 Oct. 2013 and 17 Jan. 2014 and young seedlings were transplanted on 12 Dec. 2013 and 7 Mar. 2014, respectively. Harvest took place at marketable size. Seed germination rate was lower than 50% at both sowing dates (46% and 38%, for first and second sowing, respectively), whereas seedling emergence was complete after 11 and 18 days, for the first and second sowing date, respectively.

Leaf fresh and dry weight, and rosette diameter did not differ significantly, whereas number of leaves and total leaf area was higher in the first sowing. Regarding mineral composition, Ca, Mg and Mn content was higher in the second sowing date, whereas K and Na in the first sowing date. The Fe and Zn content were not affected by sowing date. Regarding nutritional value, ash content increased in the second sowing date, whereas protein and carbohydrate content decreased. However, fructose and glucose and consequently total sugars content, and ascorbic acid content increased in the second sowing, whereas α-tocopherol and total tocopherols, and chlorophyll b decreased. Fatty acids consisted mainly of linoleic, α-linolenic and palmitic acids, whereas no significant differences were observed between the two sowing dates. PUFA/SFA and n-6/n-3 ratio was higher than 0.45 and lower than 4.0, for both sowing dates. In conclusion, sowing date affected plant growth in terms of leaf number and leaf area, without affecting leaf fresh weight, whereas second sowing resulted in an increase in sucrose, glucose and total sugars content and ascorbic acid content that could improve the taste and nutritional value of the final product.

(206) Determination and Quantification of Amino Acids in Vegetables By HPLC Fluorescence Detection
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In the present study, plant growth and mineral composition of Cichorium spinosum L. is a wild edible green, native to the Mediterranean basin, which usually grows in coastal areas and plateaus. In the present study, plant growth and mineral composition of C. spinosum was evaluated for two consecutive growing periods. Seeds of C. spinosum were sown in seed trays on 15 Oct. 2013 and 17 Jan. 2014 and young seedlings were transplanted on 12 Dec. 2013 and 7 Mar. 2014, respectively. Harvest took place at marketable size. Seed germination rate was lower than 50% at both sowing dates (46% and 38%, for first and second sowing, respectively), whereas seedling emergence was complete after 11 and 18 days, for the first and second sowing date, respectively.

Leaf fresh and dry weight, and rosette diameter did not differ significantly, whereas number of leaves and total leaf area was higher in the first sowing. Regarding mineral composition, Ca, Mg and Mn content was higher in the second sowing date, whereas K and Na in the first sowing date. The Fe and Zn content were not affected by sowing date. Regarding nutritional value, ash content increased in the second sowing date, whereas protein and carbohydrate content decreased. However, fructose and glucose and consequently total sugars content, and ascorbic acid content increased in the second sowing, whereas α-tocopherol and total tocopherols, and chlorophyll b decreased. Fatty acids consisted mainly of linoleic, α-linolenic and palmitic acids, whereas no significant differences were observed between the two sowing dates. PUFA/SFA and n-6/n-3 ratio was higher than 0.45 and lower than 4.0, for both sowing dates. In conclusion, sowing date affected plant growth in terms of leaf number and leaf area, without affecting leaf fresh weight, whereas second sowing resulted in an increase in sucrose, glucose and total sugars content and ascorbic acid content that could improve the taste and nutritional value of the final product.

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Tomato (Solanum lycopersicum L.) is one of the most commonly consumed vegetables after potato and accounts for more than $2 billion annually. In the United States, more than two-thirds of commercial fresh market tomatoes are produced in California and Florida followed by Virginia. Tomato is a good source of certain health promoting compounds, such as lycopene, β-carotene, phenolic acids and ascorbic acid. These compounds have potential to reduce risk from certain types of cancer through several mechanisms. Previous studies demonstrated that not only genotype, but also environmental factors can attribute to changes in levels of these compounds. In the present study, 36 tomato cultivars/genotypes were grown at three different locations in Texas (College Station, Uvalde, and Edinburg) during Spring 2015. Total soluble solids, acidity and pH were measured to characterize the quality and ripening ratios of tomato fruits. Ripening ratios (TSS/Acidity) ranged from 9.09 ± 0.35 to 22.89 ± 0.19. Fully ripe uniform tomatoes were analyzed for carotenoids and ascorbic acid using HPLC for the identification and quantification. The thermal environments’ effects on the levels of health promoting compounds were compared. The levels of lycopene ranged from 3.42 ± 0.06 mg/100g FW to 17.21 ± 0.59 mg/100g FW. The β-carotene concentrations ranged from 0.006 ± 0.004 mg/100g FW to 0.29 ± 0.01 mg/100g FW. The ascorbic acid levels ranged from 2.75 ± 0.01 mg/100g FW to 17.55 ± 0.6 mg/100g FW. Our recently released cultivar TAM Hot-Ty was grown in 3 locations contained the highest level of lycopene at Edinburg, where the highest average temperature was 28 °C during the last month of ripening. However the lowest level of ascorbic acid was measured under the same conditions. This high temperature effect was also evident in a commercial variety, Tasti-Lee, grown in three locations. These results illustrate that the effect of growing environment in Texas could be considered as one of critical factors for desirable bioactive compounds in tomato fruits.

Specified Source(s) of Funding: This study was supported by United States Department of Agriculture grant Designing Foods for Health through the Vegetable & Fruit Improvement Center 2010-34402-20875 and State funding 2013-121277 VFIC-TX state appropriation.
Amino acids act as building blocks for proteins, precursor for hormones, neurotransmitters, and play an important role in a plethora of metabolic pathways. They are not only essential for human health but also play an important role in plants to synthesize proteins, aid in protection as they produce in response to stress. Additionally, they are activators and precursors to phytohormones among other important functions. A method has been developed for the analysis of amino acids in vegetables by HPLC using fluorescence detector. The current method was optimized to determine the free amino acids content in beet- root, watermelon and kale. Fresh vegetables were processed using kitchen juicer, centrifuged, filtered and analyzed by pre-column derivatization. Derivatization was carried out at room temperature for two minutes with ortho-phthalaldehyde reagent. An XSelect HSS T3 column with 3.5 μm particle size (250 x 4.6 mm) was used with an oven temperature at 30 °C. The detector excitation and emission wavelengths were set at 340 and 455 nm, respectively. A total of 19 amino acids were identified with the major amino acids L-citrulline (1580.7 ± 28.1 μg·g-1), histidine (1112.1 ± 29.8 μg·g-1) and glutamine (1078.4 ± 0.7 μg·g-1) found in watermelon, beet and kale respectively. The developed method is found to be a simple and reliable for the analysis of amino acids using fluorescence detection. The present method involves simplified sample preparation and a rapid derivatization procedure.

Specified Source(s) of Funding: This study was supported by United States Department of Agriculture grant Designing Foods for Health through the Vegetable & Fruit Improvement Center 2010-34402-20875 and State funding 2013-121277 VFIC-TX state appropriation.

**Poster Session—Temperate Tree Nut Crops**

**A Prospective Study to Determine Causes of Physiological Disorder in ‘Chandler’ Walnut Fruits**

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In the last 10 years, Chilean walnut production has become an important economical activity. The industry considers internal and external features of the nut to determine its quality and price; some of the defects considered for discard are: open or imperfect shell, cracked or broken walnut, adhered hull presence and split walnut among other alterations. In ‘Chandler’ walnut fruit, a physiological disorder occurs that is only perceptible at harvest; that disorder is observed as a disruption of the endocarp structure, with high presence of perforations. Among other factors, fruit mineral content have shown an important role in determining fruit quality in different species. In the present study we made a prospection of the mineral composition of fruits, comparing element concentrations from nuts with and without symptoms of endocarp disruption. The study was carried out in a ‘Chandler’ walnut commercial orchard located in a central area of Chile. To characterize the soil, a representative sample was taken to analyse parameters such as pH, macro and micro nutrient supply. Soil fertility didn’t show deficiencies of any of the measured nutrients. At harvest, a fruit sample was taken, and then classified into groups according to visual symptoms: severe, moderately, and none endocarp disruption presence. Later, a group of 10 fruit from each level was cracked in order to split the nut into shell (nut endocarp) and seed. Dry matter and mineral concentration of nutrients were measured from each disorder level and tissue. The mineral elements measured were: N, K, Ca, Mg, Mn, Zn, Cu, Fe, and B. Shells with severe disorder symptoms had higher N, Zn and Cu concentration, and K/Mg ratio, compared with shells with moderated symptoms, and at the same time, the endocarp with moderated symptoms had higher levels compared with shells without the disorder. Shells and seeds without disorder showed higher Ca concentrations, lower N:Ca, K:Ca, and Zn:Mn ratios, compared with shells and seeds with moderated and severe symptoms. According to these results the observed disorder of the nut endocarp in ‘Chandler’ cultivar has a close relationship with an unbalanced mineral composition of the fruit.

**Soil-applied Zinc-EDTA: Effects on Dormant-season Shoot and Root Carbohydrate Storage Reserves in ‘Wichita’ Pecan Grown on an Alkaline and Calcareous Soil**

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Zinc (Zn) deficiency is common in pecan trees in the Southwestern US where soils typically have alkaline pH. At maturity Zn-deficient pecan leaves exhibit low total lamina area thickness, interveinal chlorosis, and reduced photosynthetic capacity. Low canopy-wide photosynthesis due to Zn deficiency is expected to negatively impact dormant season carbohydrate reserves. Our objective was to characterize effects of soil-applied Zn-EDTA on carbohydrate storage in shoots and roots of non-bearing ‘Wichita’ pecan. The study orchard, which has alkaline and calcareous soils, was planted in 2011. Over the course of each

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

(312) Irrigation Management of Young Pecan Trees
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A recent survey documents the planting of over 15,000 acres of new pecan [Carya illinoinensis (Wangenh.) K. Koch] orchards in Georgia from 2010-2014. Water is key to the growth of young pecan transplants; however, there are no research-based recommendations for irrigation rates on young non-bearing pecan trees. There are also many questions regarding the most efficient method of irrigating young pecan trees to get them into production quickly. The objectives of this study were to determine appropriate irrigation rates for young pecan trees and to compare growth of young pecan trees with drip and microsprinkler irrigation. Two experiments were conducted at the UGA Ponder Research Farm near Tifton, GA, beginning in 2014. The following treatments were evaluated to determine irrigation rate requirements for newly transplanted pecan trees: 1) 302 L per week; 2) 651 L per week; 3) Non-Irrigated. A separate experiment compared growth of newly transplanted trees with drip and microsprinkler irrigation using the following treatments: 1) microsprinkler at 651 L per week; 2) drip irrigation at 182 L per week; 3) drip irrigation at 651 L per week; and 4) non-irrigated. Single tree plots were arranged in a randomized complete-block design with 5 replications in both experiments. Parameters evaluated for both experiments include tree caliper, shoot growth, stem water potential (water stress), and soil moisture. Pecan tree trunk diameter increased with increasing water application rate. Pecan tree trunk diameter growth was greatest at the irrigation water application rate of 651 L per week. Both irrigation rates resulted in a greater trunk diameter increase than that of non-irrigated trees. Drip irrigation at 182 L per week resulted in similar growth as that observed for trees receiving 651 L per week using drip or microsprinklers. Each irrigation method resulted in increased trunk diameter compared to non-irrigated trees.

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Arbuscular mycorrhizal (AM) symbiosis often stimulates gas exchange rates of the host plant. This may relate to mycorrhizal effects on host nutrition and growth rate, or the influence may occur independently of these. Using ISI Web of Science, we identified 220 articles containing 1019 studies from which effects size and moderator information were extracted. Then, in a meta-analysis using meta-regression, we tested the strength of the relationship between AM-induced increases in gas exchange, and AM size and leaf mineral effects across the literature. With few exceptions, AM stimulation of carbon exchange rate (CER), stomatal conductance (g s) and transpiration rate were significantly associated with mycorrhizal stimulation of shoot dry weight, leaf phosphorus, leaf nitrogen: phosphorus ratio and percent root colonization. Increasing leaf P was positively correlated with increases in host CER and g s. Conversely, increases in the leaf N:P ratio in AM plants were associated with decreases in CER and g s. Leaf N:P response ratio was a better statistical predictor of gas exchange response to AM symbiosis than leaf phosphorus by itself. Mycorrhizal stimulation of photosynthesis, while overall about twice as large as stimulation of stomatal conductance and transpiration, has declined markedly over the 35 years of published investigations. Carbon exchange rate has been more sensitive than stomatal conductance or transpiration rate to increased percent colonization and shoot sizes. The positive correlation of percent root colonization with AM influence on CER may be related to the other regression moderators studied here; more highly infected roots may be better able to scavenge soil nutrients and plants may grow more quickly as a consequence. The results of this meta-analysis indicate that mycorrhizal influences on leaf phosphorus and plant size are positively correlated with their elevated gas exchange rates. However, the strongest correlation, leaf N:P ratio of AM plants, was a negative one.

Specified Source(s) of Funding: The University of Tennessee

(398) Differential Thermal Analyses in Peach [Prunus persica (L.) Batsch]
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The temperature at which any water freezes inside plant cells can be detected by differential thermal analysis (DTA). The results from DTA are often associated with lethal damage of flower buds. The goal of this study was to determine whether the critical freezing temperature of peach floral buds can be determined through winter by DTA. Traditional freezing tests were conducted and compared to the DTA as a standard test used to determine the lethal bud temperature at 50% mortality (LT_{50}). Floral buds of two peach cultivars, ‘Elberta’ and ‘Flavorich’, were collected during the winter of 2015-2016. DTA and freezing tolerance tests were performed every week using excised floral buds (freezing rate of 4 °C/h, temperatures ranging from –3 °C to –27 °C). High temperature exotherm (HTE) and low temperature exotherm (LTE) were clearly identified using DTA before bud swell on February 23. Peach floral buds gained cold hardiness from November to January, at which time LTE of ‘Elberta’ was -16.3°C and –21.2 °C, and ‘Flavorich’ was –12.6 °C, and –16.2 °C, respectively. Cold hardiness was gradually lost afterward. A similar trend was observed with freezing tolerance tests. In November, the LT_{50} of ‘Elberta’ and ‘Flavorich’ was –8.6 °C and –7.5 °C, respectively, and decreased to –15.0 °C and –12.0 °C right before bud swell in January. After bud swell, DTA was not able to detect LTE in peach buds. However, setting buds at -2°C overnight before running DTA greatly reduced the HTE and shifted the LTE. After setting buds at -2°C overnight, where extracellular water was frozen before DTA was started, DTA was found to be correlated with LT_{50} results (R² = 0.4831). This approach may be able to overcome the inability of DTA to detect LTE during deacclimation. Information obtained from this project provides insights to peach cold hardiness and the use of DTA to determine the critical bud temperature of peaches. DTA can provide growers with real time information that could help them in making freeze protection decisions and to estimate potential losses.

(400) Vegetative Growth, Fruit Development, and Fruit Quality of Pepper (Capsicum annuum L.) Plants Under Various Temperature Regimes

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Pepper (Capsicum annuum L.), belonging to the Solanaceae family, is an economically important crop in Korea and cultivated widely as a spice crop. Pepper plants have originated in South America and spread in a wide range of warm, subtropical and tropical regions throughout the world. During the growing season, various climatic and soil factors, including air temperature, light intensity, and precipitation, and soil conditions, have impacts on the growth and development of pepper plants. Particularly, the temperature is one of the major environmental factors impacting on processes such as flowering, fruit set, and fruit growth. In this study, we investigated the impact of temperature stress on the vegetative growth, fruit development, and the fruit quality of the plants. The temperature ranges of 20 °C to 25°C was optimum for the vegetative growth and fruit development of plants. On the other hand, the high temperature (30 °C) reduced generally the fruit development such as the fruit-set and fruit growth, although enhanced the vegetative growth. The low temperature (15 °C) caused the short shoot height, and the small number of main branches (nodes), while as resulted in the elongate fruits, and the long green fruit period. Under conditions of optimum temperature (20 °C to 25 °C) and high temperature (30 °C), the fruit development advanced by 15 and 20 days, respectively, compared to that of the plants at low temperature (15 °C). Furthermore, the fruit color change was significantly advanced in the optimum temperature (20 °C to 25°C) and high temperature (30 °C). However, high temperature (30 °C) not only reduced the number of total fruits, but also increased the number of short or malformed fruits. Total free sugar contents of red-ripe fruits were significantly higher in the optimum temperature (20 °C to 25 °C), while capsaicinoid contents of red-ripe fruits increased with the rise of temperature in the range of 15 °C to 30 °C.

(401) Environmental and Nutritional Factors Influencing Maple Tree Sap Flow

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In 2014, Canada produced 80% of the world’s maple syrup supply, with Quebec contributing to 90.5% of Canadian production. The remaining 9.5% of the supply came primarily from Ontario, New Brunswick, and Nova Scotia (NS), of which NS contributed approximately 1%. While the number of taps has...
increased over years, the average yield per tap has declined. With a farm gate value of over $1.6 million in NS alone the industry is an importation part of Nova Scotia’s economy. This study examined the tree nutritional health and impact of certain environmental factors. Experimental sites were established in ten production areas of NS. Measurements of canopy density, leaf nutrition, core nutrition, trunk circumference, soil moisture, and soil nutrition were taken each month beginning June 2015. Maple sap was collected in spring of 2016, and evaluated for yield, nutrition, and sugar content. All sites under this study had acidic soils, with the P, K and Fe being the only soil nutrients to significantly change over the months tested. Ca, Zn and Mn were found to be significantly different between sites in core tissues, with N and Fe showing significant changes over time. Leaf canopies showed differences amongst the sites as well as over time, with densities and concentration of foliar nutrients. N, K and P decreased from June to October at all sites in the leaf tissue, with an increase in Ca, Mg, B and Mn. Correlations were found between the soil and leaf Ca, K, Mn, P, Fe, Mg and Zn concentration. All explanatory variables were considered in developing a model to optimize sap yield and sugar content.

Specified Source(s) of Funding: NS Department of Agriculture, Growing Forward 2 & NS Maple Producer Association

(402) Comparison of the Nutritional Content of Quinoa (Chenopodium quinoa Willd.) Cultivated in South Korea and Peru
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The purpose of this study was to compare the nutritional content of quinoa (Chenopodium quinoa Willd.) cultivated in South Korea and Peru. Germplasm of quinoa was kindly provided by Peru in accordance with RDA-INIA collaboration subject Seven varieties (‘Salcedo Inia’, ‘Ilipa-Inia’, ‘Inia 420-Negra Collana’, ‘Variedad Amarillo’, ‘Variedad Quillahuaman’, ‘Variedad Amarillo Marangani’, ‘Variedad Inia 427 Amarillo’) that have been cultivated in South Korea. Quinoa varieties showed carbohydrate content of 69–74 g/100 g with an average of 72 g/100 g, fat content of 3.1–6.0 g/100 g with an average of 4.3 g/100 g, protein content of 13.6 g/100 g on an average, with a range of 12–15 g/100g, and crude saponin content of 21.52 to 41.40 with an average of 30.37 mg/g. In addition, calcium, phosphorus, and iron contents were analyzed. Calcium content was in a range of 97.42–138.50 mg/g with an average of 119.53 mg/g, phosphorus was 1267.92 mg/g in average, and iron content was 9.66 mg/g in average. We also analyzed the nutritional components of 4 quinoa varieties ‘Variedad Quillahuaman’, ‘Blanca Junin’, ‘Variedad Amarillo Marangani’, and ‘Variedad Inia 427 Amarillo’ cultivated in Peru. Quinoa varieties showed carbohydrate on an average of 73g/100g, fat content, on an average 3.1g/100g, ranging 2.6–3.6 g/100 g, protein content was 13 g/100 g in average, and crude saponin content showed a range of 21.40–34.74 mg/g with an average of 26.95 mg/g. Also calcium content was about 90.01 mg/g, phosphorus of 1097.84 mg/g, and iron content of 4.49 mg/g on an average, with ‘Variedad Quillahuaman’ highest with 5.58 mg/g. Nutrient content of quinoa cultivated in South Korea were higher than that of quinoa varieties cultivated in Peru. Difference of nutrients between the two countries is estimated to be due to the nutrients in the cultivated soil.

(403) The Relationship Among Fruit Growth, Sugar Accumulation, and Water Status of Seeded Watermelon and Seedless Watermelon Fruits
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Since the center part of watermelon fruits tends to be sweeter than the part near rind, sugar accumulation might occur actively there, and osmotic pressure gradients must exist toward the center to the rind. However, it has not been investigated why this osmotic pressure imbalance occurs in a watermelon fruit. In this study, we hypothesized that seeds in a fruit induce this osmotic pressure imbalance because seeds might play a role of sink which induces and accumulates photosynthate for many plant species, and the osmotic pressure of seeds expects to be the highest in a watermelon fruit. To verify this, we used three varieties of watermelon (Citrullus lanatus (Thunb.) Matsum. et Nakai) ‘Hitorijime-BonBon’ (seeded), ‘Sandia’ (seedless) and ‘SL-S2’ (seedless) for experiments. Fifteen plants for each variety were grown hydroponically and vertically in a greenhouse. The hydroponic solution was maintained 1.2 mS·cm$^{-1}$
for electric conductivities and pH 5.8. Three vines per plant were grown upward. When the vines elongated to contain more than 20 nodes, one fruit was set for each vine. The fruits were supported by ball net. We obtained the fruits at 0–45 days after pollination. The portions of the center, around the seed and near the pericarp of watermelon fruit were sampled for water status measurement and analysis for sugar contents. The water status (water potential, osmotic potential and turgor) measurement was conducted by an isopiestic psychrometer. Sugar (sucrose, glucose and fructose) contents were analyzed by using HPLC, then we calculated osmotic pressure of sugar contents by Van’t Hoff’s equation. As a result, water potentials and osmotic potentials at the tissues of center and that around seed dramatically decreased as watermelon fruits were matured. The changes of osmotic pressure calculated from the sugar contents showed similar behavior to those of the osmotic potential during fruits growth. We found these tendencies were similar at all of the varieties which we used this study, indicated that the substance which affects water status of the matured watermelon fruits is sugar, and osmotic gradients showed similar pattern whichever fruits contain seeds or not. Further physiological approach needs to consider this phenomenon.

**Poster Session—Floriculture 2**

**(290) The ASCFG: Providing Education Support and Research for Commercial Cut Flower Growers**

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The Association of Specialty Cut Flower Growers, Inc. (ASCFG), is a private non-profit organization founded in 1988 to unite and educate cut flower growers, primarily in North America. Providing information on the production and handling of more than 20 major cut flower species, and the literally hundreds of minor annuals, perennials, and woody stem species is difficult, especially for the many growing environments. By participating in the ASCFG’s online communication services, established members share their experience with newer growers. Information exchanges are archived so that topics are available for future reference. For more detailed assistance, new growers can pair with established growers in a mentor program. A quarterly magazine, *The Cut Flower Quarterly*, highlights information on current industry trends and practices, and publicizes the results of annual nationwide trials conducted by growers and other members, of new cultivars of annual and perennial cut flower species. A book providing extensive information on postharvest handling will be published this fall in response to the many issues and questions regarding the topic. Regional and national conferences bring together cut flower growers and floriculture industry representatives to share new techniques and products. The ASCFG sponsors cut flower research at two levels: 1) Trials proposed and conducted by growers on their farms, addressing specific production, marketing or handling problems. 2) Formal replicated research at universities and experiment stations by scientists and their assistants. Proposals for the latter are vetted by a 5-member ASCFG Research Foundation Board, and have typically covered topics such as postharvest handling, insect pest and disease control, as well as cultural practice management techniques. With the large number of flower species and topics, there is no lack of relevant research topics. Increasing public interest in locally sourced products and reducing the carbon footprint of purchases has spurred a strong increase in domestically produced cut flowers and in cut flower growers. As a result, ASCFG membership has risen from 530 to 950 in the last 5 years. The organization is thus an effective private delivery agency of information to a local horticultural industry.

**(291) Searching for an Optimum Supplemental LED Intensity for Winter Production of Cut Gerbera at Northern Latitudes**

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Cut flower production at northern latitudes typically requires supplemental lighting during the darker months. With LED technologies poised to overtake traditional HID for greenhouse assimilation lighting, it is important to determine the optimum supplemental LED light levels for the production of various commodities and ambient lighting conditions. Lighting manufacturers, suppliers and growers need this information to guide design and operational protocols for greenhouse production. This project investigated the production of cut gerbera (*Gerbera jamesonii* ‘Ultima’), using five levels of LED supplemental lighting (measured at pot level): 41, 76, 133, 171 and 179 µmol·m⁻²·s⁻¹ provided daily on a 12 hour photoperiod (DLI ranging from 1.76 to 7.72 mol·m⁻²·d⁻¹). Each lighting treatment was concurrently replicated four times, with two plants per plot (eight plants per treatment total). Plugs were received on 8 Oct. 2015 and transplanted into pots with coco coir media. The greenhouse environment was set at 22 °C day and 16 °C night with a constant 75% RH. Flower initiation began 45 days after transplanting (3 Dec. 2015) and flowers were harvested until 26 Feb. 2016. Vegetative growth metrics such as number of leaves and chlorophyll content index were measured biweekly. Flowering metrics including visible bud formation and flower harvest dates, stem length, flower diameter and fresh weight.

An asterisk (*) following a name indicates the presenting author.
were measured on each flower harvested. Vegetative growth metrics showed that number of leaves and chlorophyll content index increased with increasing supplemental light intensity while time between flower initiation and harvest decreased. Flower fresh weight and total number of flowers harvested increased while stem length decreased with increasing supplemental light intensity. For most metrics investigated, the 133 µmol·m⁻²·s⁻¹ (5.76 mol·m⁻²·d⁻¹) treatment was substantially better than the lower intensities while generally similar to the higher intensities.

**Greenhouse Propagation of Ornamental Ipomoea batatas Cultivars Under Light-emitting Diodes (LEDs) and Natural Light**

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Bedding plant growers are adopting new lighting technologies for faster and more vigorous establishment of unrooted bedding plant cuttings. Light emitting diode (LED) technology is quickly becoming less expensive for greenhouse installations with significantly reduced power consumption compared to high intensity discharge (HID) sodium lamps. Faster root formation with greater root mass decreases propagation time ultimately reducing crop time allowing for more turns per unit area in the greenhouse. The objective of this study was to compare the adventitious rooting of four popular *Ipomoea batatas* cultivars under LED light compared to natural light. The cultivars were ‘Black Heart’ (garnet-purple foliage), ‘Blackie’ (deep red/black foliage), ‘Margie Compact’ (lime green foliage), and ‘Tri-Color’ (white/pink/red foliage). Unrooted cuttings procured from a commercial propagator were stuck into perlite and placed under mist for 15 seconds at 10-minute intervals on 2 Feb. 2016. Half of the study was under LED supplemental light and half under natural light. The double-wall polycarbonate greenhouse included 60% shade, which was pulled for the duration of the study. The study was conducted in Fort Collins, CO (40°5853° N, 105°0844° W). The LED treatment received 16-h supplemental light (Philips GreenPower LED toplighting) and the natural day length ranged from 10 hours, 8 minutes to 11 hours, 36 minutes, start to finish. Blocks of cuttings were harvested at 2, 3, 4, and 5 weeks after stick and the fresh weight of the roots was recorded. *Ipomoea* ‘Margie Compact’ and ‘Tri-Color’ under LED light had greater root fresh weight four weeks after sticking compared to those under natural light. *Ipomoea* ‘Black Heart’ and ‘Blackie’ under LED light had greater root fresh weight five weeks after sticking compared to those under natural light.

**Silicon Accumulation and Distribution in Petunia and Sunflower**

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Silicon (Si) is a beneficial element that has been shown to protect plants during periods of abiotic and biotic stress. Plant-available Si can be supplied through substrate components, substrate amendments, liquid fertilization, or foliar sprays. The objective of this study was to compare Si accumulation and distribution in plants grown in a Si-amended and non-amended substrate. The base substrate was 85% peat:15% perlite, with incorporation of either 0% or 20% parboiled rice hulls (by volume). Seedlings of petunia (*Petunia hybrida* ‘Dreams Pink’), a low-Si accumulator, and sunflower (*Helianthus annuus* ‘Pacino Gold’), a high-Si accumulator, were transplanted into 11.5-cm pots. Greenhouse conditions were maintained at 22 °C day/18 °C night, with a 14 h photoperiod and supplemental irradiance from high-pressure sodium lamps when ambient irradiance was less than 300 µmol·m⁻²·s⁻¹ photosynthetically active radiation. Plants were irrigated as needed with 20N–4.4P–16.6K at a concentration of 150 mg·L⁻¹ N. They were harvested when all had flowered, 53 and 72 days after transplant for petunia and sunflower, respectively. Leaf, stem, and root Si concentrations (mg·kg⁻¹ dry weight) were higher in petunia plants grown in the rice-hull amended substrate, but flower Si concentration was similar in both treatments. Sunflowers had higher Si concentrations for all tissues (roots, leaves, stems, and flowers) when grown in the rice-hull amended substrate. Of the total plant Si accumulated in petunias grown in the rice-hull amended substrate, approximately 72% accumulated in leaves, 17% in stems, 5% in flowers, and 6% in roots. In sunflower, Si distribution in plants grown in the rice-hull amended substrate was 91% in leaves, 3% in stems, 3% in flowers, and 3% in roots.

**Cuphea Species and Cultivars Differ in Occurrence of Intumescence**

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*Cuphea* (*Cuphea* spp.) are herbaceous ornamental plants that are being more widely produced in greenhouses because of their unique flower morphology, profuse flowering, and ability to perform well in heat and drought in the landscape. However, some species and cultivars are susceptible to intumescence, a physiological disorder characterized by abnormal cellular outgrowths on the leaf surface. In severe cases, the leaves are nearly completely covered with the outgrowths, and leaves begin to curl, resulting in unsalable plants. With many recent cuphea introductions, we conducted a screening trial of 23 ornamental...
cuphea species and cultivars to document intumescence occurrence and severity, and to characterize plant growth habit, floral characteristics, and leaf morphology. Two different groups of plants were grown in a glass greenhouse under polyethylene with UV-block for six weeks. Plants were replicated across six blocks with three pots per experimental unit that allowed for destructive evaluation of one pot per experiment unit every two weeks. Plants were rated based on overall intumescence using a scale from 0 to 5 (0 = no intumescence and 5 = severe) and yhr percentage of leaves with intumescence. In the first group (4 Feb. through 16 Mar.), only four out of the 11 cultivars developed intumescence. Intumescences were observed within two weeks of initiating the study, and severity increased throughout the study for those that developed intumescences. Intumescence was most severe on C. llavea selections, including ‘Flamenco Samba’ and ‘Tiny Mice’, in which average plant ratings were between 4 and 5 after four weeks. In the second group of 12 cultivars (8 Mar. through 20 Apr.), intumescence was observed on four cultivars, including three different Sriracha™ selections and ‘Georgia Scarlet.’ Similar to the responsive cultivars in the first group, the cultivars that developed intumescence in the second group were also C. llavea hybrids. These results will aid greenhouse growers in selecting cuphea varieties for production that do not develop intumescence if they are produced in a UV-deficient protected environment.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation

(295) Effect of Medium Composition on the Lower Leaf Yellowing of Phalaenopsis Plantlets In Vitro

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Phalaenopsis is currently the most popular floral crop in the world; the high demand for plant supply is met through tissue culture. During its in vitro propagation, lower leaf yellowing in Phalaenopsis plantlets was observed in some susceptible cultivars. This study investigated its potential causes in regard to medium composition. Plantlets of Phalaenopsis Brother Pico Bahama ‘E.G.’ were subcultured with four basal media, namely half-strength Murashige and Skoog (1/2 MS; control), Hyponex #1 at 3 g·L⁻¹ (HP), Hyponex #1 at 1.5 g·L⁻¹ + Peters Excel 15–5–15 Cal-Mag at 1.5 g·L⁻¹ (HP-PE), and Peters Excel 15–5–15 Cal-Mag at 3 g·L⁻¹ (PE). HP resulted in the most severe leaf yellowing, with 2.0 yellowed leaves per plantlet against just 0.3 in the control group. The number of yellowed leaves decreased as concentration of Hyponex decreased, which was 2.0, 1.1, and 0.6 for the HP, HP-PE, and PE, respectively. The ethylene concentration in the culture vessel corresponded to the severity of leaf yellowing, with highest ethylene concentration in HP (14 nL·L⁻¹) and lowest in 1/2 MS (7.2 nL·L⁻¹). The incorporation of organic additives (i.e., apple, banana, or potato) into the culture medium also resulted in more yellowed leaves and higher ethylene concentration in the vessel. For the tissue culture of Phalaenopsis cultivars that are prone to lower leaf yellowing, it is thus suggested to reduce the use of Hyponex #1 and certain organic additives.

Specified Source(s) of Funding: Ministry of Science and Technology, Taiwan

(296) Application of Ice to Phalaenopsis Orchid Roots Does Not Affect Quantum Efficiency of Photosystem II

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The use of ice to irrigate plants has been an accepted practice for over 25 years. Recently, a company that recommends this practice for watering orchids was challenged by an orchid society to prove that ice was not detrimental to orchids. To address this question, we conducted two different studies using chlorophyll fluorescence measurements to determine if this procedure causes root damage: 1) The internal temperature of Phalaenopsis orchid roots was monitored using a micro-thermcouple placed deep inside the stele of the root as an ice cube was placed directly on the root and 2) the quantum efficiency of the photosynthetic spongy parenchyma of the orchid root was assessed in a time study where roots were immersed in a bath filled with anti-freeze. The temperature of the anti-freeze solution was lowered two degrees every hour until the roots showed signs of freezing. Freezing was evident when the exothermic reaction of ice crystal formation expressed itself as a jump in the tissue temperature. Freeze damage was also assessed by determining the quantum efficiency of photosystem. Our results showed that when ice cubes were placed directly onto the root surface, internal root temperatures dropped quickly, but never below 2 °C. In the second study, roots did not show freeze-induced damage until the temperature of the water bath reached –7 °C, at which time the internal temperature of the roots reached –2 °C. The quantum efficiency of photosystem II dropped from about 0.75 in healthy roots to 0.17 in freeze-damaged roots. This drop in quantum efficiency is likely due to the cell membranes in the roots being compromised by ice crystal formation. The below 0 °C freezing point may be due to sugars and other solutes in the root tissue. In summary, the internal temperature of roots with an ice cube placed on top did not drop below 2 °C (38.6 °F), while freeze-induced damage in the roots was seen only at root temperatures below –2 °C. There is no evidence of root damage based on the quantum efficiency of photosystem II when ice is placed directly on the root. Long-term studies with the use of ice cubes compared to conventional watering are being conducted to look at how ice cubes may affect plant health and flower longevity long term.

Specified Source(s) of Funding: Green Circle, Inc.

An asterisk (*) following a name indicates the presenting author.
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growth of these native plants to our culture. To raise awareness and to help our people realize the connection to local, regional, and national issues, the Guam Forestry Division, and the Department of Defense, to work together with private landowners and local agencies, such as the U.S. Fish and Wildlife Services, the U.S. National Park Service, the Guam Forestry Division, and the Department of Defense, to establish a program that would help preserve and grow native plants. This program is called the Guam Plant Extinction Prevention Program (GPEPP) and was established to set up new populations of rare native plant species throughout Guam. This is accomplished through the following tasks: surveying and monitoring, propagation in the rare plant nursery, and out-planting. The GPEPP also works to identify and address biological, climatic, and physical barriers. To prevent the loss of native plants, the Guam Plant Extinction Prevention Program (GPEPP) was established to set up new populations of rare native plant species throughout Guam. This is accomplished through the following tasks: surveying and monitoring, propague collection, seed storage, tissue culture, propagation in the rare plant nursery, and out-planting. The GPEPP also works with private landowners and local agencies, such as the U.S. Fish and Wildlife Services, the U.S. National Park Service, the Guam Forestry Division, and the Department of Defense, to raise awareness and to help our people realize the connection of these native plants to our culture.

(071) Preserving Guam Rare Native Plants through a Plant Extinction Prevention Program

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Plant endemism occurs in island communities because of biological, climatic, and physical barriers. Due to the recent changes in climate and the introduction of invasive species, native plants are now at risk of extinction, which would change Guam’s landscape and threaten its biodiversity. To prevent the loss of native plants, the Guam Plant Extinction Prevention Program (GPEPP) was established to set up new populations of rare native plant species throughout Guam. This is accomplished through the following tasks: surveying and monitoring, propagation in the rare plant nursery, and out-planting. The GPEPP also works with private landowners and local agencies, such as the U.S. Fish and Wildlife Services, the U.S. National Park Service, the Guam Forestry Division, and the Department of Defense, to raise awareness and to help our people realize the connection of these native plants to our culture.

Specified Source(s) of Funding: Indian Council of Agricultural Research (ICAR) -Krishi Vigyan Kendra, Bengaluru Rural district, Karnataka, India

(072) Krishi Vigyan Kendra—A Farm Science Center for Sustainable Rural Livelihoods

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Krishi Vigyan Kendra (KV) is the only institution at the district level in India for technological backstopping in agriculture and allied sectors. It is envisaged to reduce the time lag between generation of technology at the research institutions and its application to the location specific farmer fields for increasing production, productivity and net farm income on a sustained basis. ICAR, Krishi Vigyan Kendra, Bengaluru Rural District (ICAR KVK-BRD), Karnataka, India is serving the farming community of the district through identification of location specific problems and resolving them by conducting on farm testings (OFT), frontline demonstrations (FLD) and need based trainings. Feedback to the research system about field problems, production and supply of quality seeds and planting material and serving as an expert center in the district are the other key roles performed by this KV. The efforts of KV mandated activities have resulted in over 30% adoption of improved technologies, with 20% increase in crop production and quality. This has led to 35% higher income and improved economic status of the farmers. External funding of Rs. 33.00 million was mobilized through effective linkage with developmental departments. About 60,000 farmers were sensitized on advanced technologies through 2,300 outreach programmes. KV has motivated 80 rural youth for self-employment through vocational trainings who are now recognized as master trainers in farmer led extension. Impact studies revealed landslide change in livelihood security and socio-economic status by adopting Integrated Farming System Demonstration (IFSD) model. Effective market linkage was assured through empowering 11 Commodity Based Associations and 49 Self Help Groups in value addition, branding and marketing of food products. The team of ICAR-Krishi Vigyan Kendra, Bengaluru Rural District has bagged the “Zonal Best Krishi Vigyan Kendra Award–2012” and “National Best Krishi Vigyan Kendra Award–2014” for its outstanding achievements. KV staff received 14 awards for their extension outreach activities. This KV is recognized as a center of scientific agricultural resources for the farmers and extension personnel of the district.

Specified Source(s) of Funding: Indian Council of Agricultural Research (ICAR), Krishi Vigyan Kendra, Bengaluru Rural district, Karnataka, India

(073) Impact of Sack Gardening By Youth in a Ugandan School Garden Program

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School garden programs (SGPs) provide experiential learning to develop pupils’ agriculture skills for future livelihoods in developing countries. The Iowa State University, SGP in Uganda conducted a sack gardening workshop in 2013 in the Kamuli District at Namasagali Primary School. The goals of the program were to educate youth about sack gardening, a low-input,
small-scale production system, and provide materials for youth to construct their own sack gardens at home. Sack gardens are constructed by using 100-kg feed sacks, filled with soil placed on top of 23 cm of 4-cm diameter rocks. Vegetables are produced in slits cut into the sack’s sides and in the open top. Sack gardening provides for the production of vegetables in a small area. Youth may consume the vegetables with their families or generate income by selling the vegetables. In 2015 a follow-up survey was completed with the youth participants of the 2013 sack gardening workshop. Forty-eight pupils participated in the 2013 workshop. Forty-one pupils were believed to be living in the district and available to survey. We completed assent, consent, and surveys with 21 pupils (51%). Of the 21 pupils surveyed, all (100%) remembered the workshop, described sack gardening, and stated the steps needed to create a sack garden. Eighty-six percent of survey respondents harvested produce and considered their first sack garden successful. Thirty-eight percent of surveyed pupils continued using sack gardens after the first crop, and 5% currently use sack gardens. When asked why pupils quit using sack gardens, 36% of survey participants responded that they had no access to vegetable transplants, 13% moved into boarding school and could not continue sack gardening, and 10% moved within the district and did not have the opportunity to continue sack gardening. The 2013 sack garden workshop educated youth about using sack gardens for vegetable production. All 21 pupils surveyed remembered the workshop and sack gardening methods, demonstrating both change in knowledge and retention of new knowledge. When asked about additional sack garden training, pupils’ comments indicated that they valued the experience and were interested in continuing sack gardening. Based on the reasons why pupils discontinued using sack gardens and their interests, additional training for pupils about investing profits from sales of vegetables into supplies for future sack gardens, proper methods of saving seed and producing transplants, and how boarding school pupils might create or find sack gardening space is recommended.

(074) Creating Partnerships: Mississippi State University, Tennessee State University, and University of Jeremie

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Reginald Archer
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In January 2016, a group of academics and agricultural experts conducted a week-long program at the University of Jeremie (UJ) in Jeremie, Haiti. The “Farmers Without Fences” group consisted of Dr. Christine Coker, Associate Research and Extension Professor of Urban Horticulture, Mississippi State University (MSU); Christian Stephenson, Hancock County Director, Mississippi State University Extension Service; Dr. Reginald Archer, Assistant Professor of Applied GIS, Tennessee State University (TSU); Kenny Swann, Bill Seeley, and Mike Hendley, farmers, Robertson County, Tennessee; and Louis Buck, International and Market Development Specialist, Tennessee Department of Agriculture. The trip consisted of a combination of tours, classroom instruction, and field demonstrations. The University of Jeremie began offering classes in 2012. The university offers degrees in teaching, nursing, theology, business, and agriculture. Over 130 students are presently enrolled in the agriculture program. Instruction was presented seminar style with first through third year students in attendance. Topics included plant pathology, vegetable production, irrigation, and geospatial information systems. Seminars were translated from English to Creole by university faculty. In addition to classroom instruction, students and instructors toured the university’s agricultural plots and worked with students about current production challenges. One of the main challenges identified was irrigation. Currently, water is collected in two cisterns at the edge of the field. Water is then carried in watering cans, and plants are hand-watered individually. Both students and faculty met a demonstration of drip irrigation with interest. Continued relationship building between UJ and MSU, and TSU would enable greater capacity for UJ faculty and students to expand their agricultural programs. A memorandum of understanding has recently been reached between the University of Jeremie and Tennessee State University. Plans are underway to pursue a similar arrangement with Mississippi State University.

(075) Evaluating Horticultural Practices for Sustainable Tomato Production in Kamuli, Uganda

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Tomatoes are a source of income and contribute to food security for small-landholder farmers in Uganda, including the Kamuli District. Evaluation of sustainable production practices is needed to improve farmers’ livelihoods. Four treatments and their objectives were included in the study; 1) evaluate three tomato cultivars (Heinz 1370, Nuru F1, and MT 56) for disease resistance and potential yield, 2) quantify any effect of pesticide applications on tomato yield, 3) compare staking practices’ impact on disease occurrence, and 4) evaluate the influence of mulching on disease occurrence and yield. The experimental design was a randomized complete block design with a factorial and split-plot arrangement of treatments during two growing seasons of 2013. Total and marketable number of fruit, marketable fruit weight, gross margin, and disease severity were measured for each treatment. Disease severity was assessed using the area under the disease progress curve. In season one, results indicated that...
disease-resistant cultivar MT 56, in combination with pesticide application and soil mulch, provided the greatest marketable fruit number and marketable fruit weight, and all treatments had a positive gross margin. In season two, a combination of ‘Nuru F1’, pesticides and mulch produced the greatest total and marketable fruit number, and fruit weight. A combination of ‘MT 56’, no pesticide application, and no mulch was the only treatment with positive gross margin in the second season. Applying pesticides reduced disease severity of early blight, Alternaria solani, for all cultivars in season one and for Heinz 1370 and Nuru F1 in season two, but did not affect disease severity for MT 56 in the second season. Using soil mulch reduced the severity of early blight disease, but decreased the gross margin when purchased. Staking did not affect yield or disease severity of plants and decreased the gross margin. Based on these results, we recommend tomato growers produce ‘MT 56’. Applying pesticides according to label recommendations and using soil mulch may increase yields and protect tomato plants and fruits from A. solani depending on cultivar and season. The availability of ‘MT 56’ tomato seed makes implementing the recommended cultivar, MT 56, difficult. Follow-up studies are being conducted to analyze the tomato seed value chain in Uganda to understand the availability of superior cultivars and hybrids.

(076) Current Tomato Seed Management Practices Among in- and out-of-School Youth in Kamuli, Uganda

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Seed is a critical input to grow crops successfully and contribute to food security. High quality seeds are essential for small-landholder farmers who produce tomatoes in the developing world. In- and out-of-school youth often lack agriculture production skills and inputs, including seeds. A research project determined tomato seed management practices used by youth farmers in the Kamuli District, Uganda. Surveys were administered to 60 in- and out-of-school youth in summer of 2015 and included only those youth who grew tomatoes and were part of the Iowa State University, Youth Entrepreneurship Program (YEP) in Uganda. The YEP program teaches in- and out-of-school youth about entrepreneurship and crop and livestock production and management practices. Preliminary results indicated that 35% of youth survey respondents saved seed, while 65% did not. Most youth tomato growers received knowledge about seed saving from fellow farmers. Of those youth saving seed, most did not track which tomato cultivars they saved. Among those who could identify cultivars, open-pollinated Rio Grande was the cultivar most commonly saved. Saved seeds were stored in plastic containers and kept in the main house where youth lived. They controlled for seed borne disease by dusting seed with kitchen ash and did not use protective clothing or gear if they used fungicides. Youth farmers agreed with the statement that they can save money and reproduce a desired cultivar with seed, but had inadequate knowledge about seed-saving techniques, which also was the most common reason for not saving seeds. Saving seed can be a sustainable production option for farmers growing non-hybrid tomatoes and Kamuli District youth who have limited funds for agricultural inputs. Based on these results, Iowa State University YEP program should include education about proper seed saving techniques. The quality of available seed at affordable prices in the Kamuli market also should be improved to benefit youth farmers currently not saving seed.

Poster Session—Ornamentals/Landscape and Turf 2

(313) Response of Seven Woody Ornamentals to Turfgrass Herbicide Applications of Arylex, Penoxsulam, and Pyrimisulfan

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With the recent stop-sale and distribution by the EPA in 2011 of aminocyclopyrachlor for use in turfgrass systems due to reported tree harm, many newly registered turfgrass herbicides are intensely tested for ornamental damage. New herbicides that have shown effective weed control in turfgrass systems are arylex, penoxsulam and pyrimisulfan. The objective of this study was to investigate the influence of turfgrass applications of arylex, penoxsulam and pyrimisulfan herbicides on seven common woody ornamental landscape species. Research trials were initiated on a nursery production facility at the Tuttle Forestry Research Center in Manhattan, KS. Seven ornamental species were tested included; blue spruce (Picea pungens ‘Glaucia’), eastern redbud (Cercis canadensis), red maple (Acer rubrum ‘Sun Valley’), burl oak (Quercus macrocarpa), elm (Ulmus parvifolia ‘Frontier’), viburnum (Viburnum x rhytidophyllodes ‘Allegheny’) and limber pine (Pinus flexilis ‘Vanderwolf’s Pyramid’). Individual species were grown 19 L nursery pots. Herbicide treatments included; pyrimisulfan (0.18 kg ha⁻¹ a.i.), pyrimisulfan (0.36 kg ha⁻¹ a.i.), pyrimisulfan (0.18 kg ha⁻¹ a.i.) + penoxsulam (0.18 kg ha⁻¹ a.i.), pyrimisulfan (0.27 kg ha⁻¹ a.i.) + penoxsulam (0.27 kg ai ha⁻¹), aminocyclopyrachlor (1.52 kg ha⁻¹ a.i.), arylex (0.02 kg ha⁻¹ a.i.) + fluoxyypyr (0.32 kg ha⁻¹ a.i.) + dicamba (0.28 kg ha⁻¹ a.i.), arylex (0.02 kg ha⁻¹ a.i.) + fluoxyypyr (0.3 kg ha⁻¹ a.i.) + 2,4-D (2.2 kg ae ha⁻¹), 2,4-D (2.67 kg ha⁻¹ a.i.) + MCPP (0.71 kg ha⁻¹ a.i.) + dicamba (0.24 kg ha⁻¹ a.i.) and a non-treated control. Treatments were applied 3 Aug. 2015, and arranged as randomized complete design with three replications within each species. Liquid herbicide treatments were applied in 8 fl oz of water to the soil surface of each individual species. Granular treatments we applied to soil surface by hand then watered in with 8 fl. oz. All treatments were applied to simulate common turfgrass application. Visual phytotoxicity (0% to 100% scale) was conducted monthly throughout the experiment. Data

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

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were subjected to ANOVA in SAS and means were separated according to Fisher’s Protected LSD at $P = 0.05$. No injury was observed on blue spruce, limber pine and red maple regardless of treatment throughout the experiment. Unacceptable injury was observed by aminocyclopyrachlor applications at 0–57 DAA (days after application) on eastern redbud, elm and viburnum. High Pyrimisulfan + penoxsulam rates at 57 DAA also resulted in slight < 40% elm phytotoxicity, significantly greater than non-treated. Results indicate high herbicide safety on select landscape ornamentals of developing turfgrass herbicides.

(314) Does Knowing Native Grass Benefits Influence Customer Purchases?
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Native grasses, such as Koelreuteria macrantha (junegrass), Schizachyrium scoparium (little bluestem), and Sporobolus heterolepis (prairie dropseed), can be an essential component to urban and suburban landscapes as they provide numerous ecosystem services; however, many of their benefits are widely unknown outside the scientific community. The objective of this project was to determine if displaying educational signage in garden centers would increase gardener’s awareness of these benefits and influence them to purchase native grasses. We designed and displayed four 22” x 28” double-sided posters and five-thousand 2” x 4.5” customized plant tags at four Minnesota garden centers to educate consumers on the benefits of native grass. The signs showed pictures of Minnesota native grasses, butterflies, and songbirds, and listed four benefits of native grass; attract wildlife such as songbirds and turkeys, feed more than 75 butterflies and moths, reduce soil erosion, and require no pesticides or fertilizers. The educational impact of the signage was determined by interviewing customers on site in the garden centers to measure their knowledge of native grass benefits after viewing the signs. Customers were asked the following questions. 1) Do you recall seeing the signs and displays of native grasses? 2) After seeing the display did you purchase one or more native grass plants, examine the native grasses, or consider purchasing a native grass in the future? 3) Have you ever purchased a native grass before today? 4) How would you rate your knowledge on the benefits of native grasses? 5) True or false: Native grasses need a lot of water and fertilizer; Native grasses attract wildlife such as songbirds and turkeys; Native grasses help reduce soil erosion; Native grasses attract a lot of pests; Native grasses feed more than 75 butterflies and moths. 6) Agree or Disagree: If I knew native grasses helped butterflies, moths, and songbirds I would be more willing to purchase them; Even if a plant looks plain but a sign shows it reduces soil erosion and needs no pesticides or fertilizer, I would be more willing to purchase it. The responses to these questions were evaluated to determine how effective the signage was in educating customers and influencing them to purchase native grasses. We hypothesized that increasing consumer awareness of the benefits of native grasses will increase the sales of native grasses, thus supporting the business of our local economy and leading to more diversified landscapes to support our local ecosystems.

(316) U.S. Non-collegiate Golf Course Superintendent’s Perception of the Audubon Cooperative Sanctuary Program
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The Audubon Cooperative Sanctuary Program (ACSP) is administered by Audubon International as a partnership with the United States Golf Association that recognizes sustainable golf course management practices. The six categories of ACSP certification are: 1) Environmental Planning; 2) Wildlife and Habitat Management; 3) Chemical Use Reduction and Safety; 4) Water Conservation; 5) Water Quality Management; and 6) Outreach & Education. Currently, only 13% of the estimated 15,000 golf courses in the United States have achieved some level of ACSP certification. A survey was conducted to determine the level of ACSP certification of U.S. non-collegiate golf courses and the interest in student involvement in the certification process. A cross-sectional, self-administered online questionnaire was administered to a random sample of 1500 superintendents at non-collegiate golf courses in the United States. The survey had 263 responses representing superintendents located in 46 U.S. states. Data was analyzed using Chi-square, Spearman’s rank correlation, and Cox multiple regression analysis. Twenty-eight percent of U.S. non-collegiate golf course superintendents identified their course as having some level of ACSP certification. The main reasons for achieving certification were identified as environmental stewardship, prestige, a directive from a governing board, and reduction of management inputs. The most challenging aspects of certification were time, the application process, and labor. When asked to rate the difficulty of achieving certification in each ASCP category, the majority of superintendents rated all categories either neutral or easy, except for Outreach and Education, which was rated as neutral to difficult. Fifty percent of the superintendents on courses not ACSP certified are interested in pursuing certification and the main reasons identified as barriers to certification were lack of time, budget, and the time involved in the certification process. Superintendents identified an average of 3 four- or two-year colleges located near their course. Of these schools, 57% were...
identified as having agricultural, horticultural, or turfgrass programs. On average, superintendents reported an academic class visits their non-collegiate golf course once every three years. Although 34% of superintendents reported having students involved on their course, only 6% said student activities were educational. Despite this, 85% of superintendents would favor student involvement in the ACSP certification process. Approximately half of the U.S. superintendents on non-ACSP certified courses are interested in pursuing ACSP certification. A high interest in student help, coupled with close proximity to four- and two-year colleges with agricultural, horticultural, or turfgrass programs creates the opportunity to overcome identified barriers to certification.

(317) Educational Needs of Turf and Landscape Industry Workforce in Reno-Sparks Metropolitan Area
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For more than a century, the University of Nevada, Reno, as well as the Nevada System of Higher Education has not effectively embraced horticulture and landscape programs. The population of Reno–Sparks Metropolitan Area has been growing rapidly over the last two decades and demographic predictions suggest a further increase. Growing acreage of home lawns, parks, golf courses and other turf areas calls for the efficient management of scarce water resources as well as appropriate management of weeds and insect pests in the Northern Nevada. Presently, around one hundred businesses in the area offer some type of turf and landscape service. Employees having formal horticultural education dominate management positions in larger companies but ordinary workers receive only on-site training and learn their skills on the job. There is an apparent need for formal education in addition to basic training. Over the period of six winter months I have visited employees involved with various types of turf and landscape management responsibilities and I have conducted surveys assessing their professional educational needs. Results of these surveys and analysis of collected data will be presented and discussed.

(318) Impact of Parboiled Rice Hull-amended Substrates on the Growth and Quality of Geranium
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Utilizing alternative, low cost, and renewable substrates to create growing mixes is an important strategy for sustainable greenhouse and nursery production. Parboiled Rice Hulls (RH) are an agricultural byproduct from rice mills, and have been suggested as a viable substitute to peat moss. This study was conducted to assess the impacts of replacing non-renewable peat moss in standard growing medium with RH on the production and quality of geranium (Pelargonium xhortorum ‘Bullseye Scarlet’). Plants were transplanted into 6-inch plastic containers filled with a substrate composed of commercial potting mix (CPM, 70% peat moss), or amended mix either with ground rice hulls (GRH, 30% peat moss and 40% ground rice hull) or whole rice hulls (WRH, 30% peat moss and 40% whole rice hull). Plants were fertigated to maintain 30% leaching fraction. Plant growth and flowering parameters such as plant height, growth index, leaf number, leaf area index, and inflorescence number and size were assessed throughout the study. It was found that CPM increased leaf number, leaf area and biomass by 45% compared to RH. However, plants grown in GRH and WRH produced uniform, denser and shorter plants whereas plants grown in CPM produced non-uniform, more spreading and taller plants. Plants grown in RH were about 50% shorter and 25% more compact than those grown in CPM. Even though plant height was similar when grown in WRH and GRH, WRH-grown plants were around 10% more compact than those grown in GRH. Flowering characteristics such as flowering initiation, height of flower stem and average size of fully open inflorescence were similar between plants grown in RH-containing substrates and CPM. Based on the results, it is evident that RH could be used as a promising alternative to peat moss for growing geraniums.

(319) Effect of Nitrogen Level on Rate of Decomposition of Plantable Containers in the Landscape
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Environmental concerns by consumers and the green industry have increased interest in plantable containers. These containers serve as alternatives to petroleum-based plastic containers due to their ability to eliminate plastic waste and disposal, facilitate efficient planting, and produce marketable plants. Recent research reports alternative containers have provided similar or greater performance of plants grown in these containers. However, little information has been provided about degradation of plantable containers in the landscape. Factors including pH, nitrogen, soil type, moisture, temperature, and microbial activity can influence biodegradation of plantable containers. It is imperative that these containers break down as claimed because rate of biodegradation can affect plant health and performance. A litterbag study was conducted at two locations at the University of Georgia Griffin Campus (Spalding Co., GA) to evaluate the effect of soil type (Dempsey Farm: sandy clay; pH 5.01; nutrients (mg/kg) Ca = 399.0; K = 136.2; Mg = 85.2; P = 5.93, Bledsoe Farm: sandy clay; pH 4.77; nutrients (mg/kg) Ca = 230.0; K = 135.9; Mg = 43.9; Mn = 11.6; P = 12.3) and nitrogen fertilizer on decomposition of commercially-available containers: coconut coir fiber, processed cow manure, and wood pulp fiber over a six-month
Poster Session—Pomology 2

(252) Molecular Bases of Apple Flowering Inhibition By Defoliation and Gibberellins

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Flowering plays an important role in the apple industry. There are many issues associated with apple flowering especially with some high value cultivars such as Honeycrisp. It has been well established that gibberellins and defoliation treatments can inhibit flower formation. Such inhibition is likely preceded by changes in gene expression. In this study we are trying to understand how local gibberellins, and defoliation treatments inhibit flower formation. We hypothesized that local application of gibberellins or defoliation treatments inhibit flowering via altering the expression of the genes MdFT1 and MdTFL1. Exogenous gibberellins and defoliation treatments were applied to bourses on Honeycrisp apple trees at times previously shown to inhibit flower formation. Samples were collected throughout the growing season to observe flower formation and to investigate the change in MdTFL1 and MdFT1 gene expression. Both local defoliation and gibberellins treatments inhibited flower formation. Quantitative PCR was used to measure the effect of different treatments on MdFT1 and MdTFL1. Results showed that both genes had lower expression levels in response to defoliation treatments, and increased their expression levels in response to gibberellin treatment. This increase in MdFT1 and MdTFL1 expression level in response to local gibberellins treatments associated with inhibition of local flower formation could be an indication that gibberellins inhibit flower formation in apple by inhibiting genes downstream of MdFT1.

(253) Washington Regional Cider Apple Juice Characteristics

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In this study, four cider apple (Malus domestica Borkh.) cvs, Brown Snout, Dabinett, Kingston Black, and Yarlington Mill, were collected from four orchards, in northwest Washington (WA), Alpenfire Cider and Washington State University Northwestern Washington Research and Extension Center (WSU NWREC), and two in central WA, Snowdrift Cider Co. and Tieton Cider Works, to compare juice quality characteristics. Northwest WA has a cool, humid summer climate (16.0 °C on average during this study) and is the origin of the state’s cider apple industry, while central WA has a hot, dry summer climate (22.1 °C on average) and is the center of the state’s dessert apple industry. Each year from 2012 to 2015, one crate each of the four cultivars was collected from the four orchards, fruit were pressed, and the juice analyzed for five quality characteristics: soluble solids concentration (SSC, %), specific gravity (SG), pH, titratable acidity (TA, malic acid g·L⁻¹), and tannin (tannic acid %). Harvest dates and climate data were recorded annually for each orchard location. There were no significant differences in any of the juice quality characteristics due to region and no significant interaction of region, cultivar, and/or year. Results did show a significant difference in all five juice characteristics due to cultivar. ‘Brown Snout’, ‘Dabinett’, and ‘Kingston Black’ were higher in SSC and SG than ‘Yarlington Mill’; ‘Dabinett’ had the highest pH and lowest titratable acidity while ‘Kingston Black’ had the lowest pH and highest titratable acidity; and tannin was highest in ‘Yarlington Mill’ and lowest in ‘Kingston Black’. There was also a difference in SG and tannin due to year; SG was lowest in 2013 while tannin was highest in 2012. The difference in SG from year to year may be a result of variable year-to-year cold storage time of fruit prior to pressing as SG can increase during cold storage. The difference in tannin from year to year was likely due to climactic variation over the four years. On average, growing degree days increased 10% and chilling hours decreased 10% from 2012 to 2015 in both regions. Results from this study indicate variations in juice quality characteristics occur between cultivars annually and for some characteristics such as SG and tannin within a cultivar from year-to-year. These results indicate that for the four cultivars included in this study there was no significant variation in juice quality characteristics due to production region in Washington.

Specified Source(s) of Funding: WSDA, WSU CSANR, NARF, Northwest Cider Association, and NIFA Hatch Project (WPN00427)

(254) Fire Blight Tolerant Asian Pear Cultivars for Alabama

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Asian pear trees are quite precocious and productive. Nine Asian pear cultivars namely ‘Hosui’, ‘Isilwase’, ‘Kosui’, ‘Olympic’, ‘Shinko’, ‘Ya Li’, ‘Yoinashi’, ‘Atago’, ‘Shinsui’, and two European pear cultivars ‘Golden Russett’, and ‘Bartlett’, were planted at the Chilton Research and Extension Center near Clanton in the spring of 2010 to field-test currently available fire blight tolerant Asian pear cultivars for their adaptation to Alabama conditions. The experiment is part of a multi-state replicated trial set in eight locations across the eastern United States to assess Asian pear cultivars potential for growers focused on producing sustainable fruit crops for local and regional markets. Trees began flowering and fruiting in their second leaf and measurements of fruit quality began in the third leaf. Tree survival varied considerably among cultivars. By the end of the third season, all five ‘Bartlett’ trees were dead, and only 60% of ‘Golden Russett’ trees survived. All of the ‘Hosui’ trees were dead by the end of the fourth season. Cultivars ‘Ya Li’, ‘Ishiwase’, and ‘Shinko’ were vigorously growing by the end of the fifth season, while ‘Atago’ was the least vigorous based on TCSA measurements. Blooming of ‘Ya Li’ occurred early in the season, one to two weeks before other cultivars in the experimental plot blossomed. This indicates the importance of planting ‘Ya Li’ with a companion early blooming pollinator cultivar such as ‘Ya Tse’. ‘Yonashi’ produced 26.3 kg/tree cumulative yield followed by ‘Olympic’ with 26.1 kg/tree during 2013–15 harvest seasons and were the most productive cultivars. ‘Ishiwase’, ‘Kosui’, ‘Yonashi’, ‘Olympic’, and ‘Atago’ produced large fruit with mean fruit size between 203 and 236 g. ‘Kosui’ was the earliest maturing cultivar based on chlorophyll level and leaf area measurements. No significant differences in chlorophyll level and leaf area were found between studied cultivars. Our preliminary results indicate that selected Asian pear cultivars could be successfully grown on a small scale for local markets.

Specified Source(s) of Funding: Alabama Tree Fruit and Nut Industries

(255) Apple Anthracnose Life Cycle and Disease Cycle
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Apple anthracnose [caused by Neofabraea malicorticis (H.S. Jacks) anamorph Cryptosporiopsis curvispora (Peck)] is a fungal disease that impacts apple production. The pathogen produces cankers on trees as well as a rot on the fruit known as ‘Bull’s-eye rot’. The cankers cause severe damage to trees, can kill newly planted trees, and is limiting long-term orchard productivity in western Washington and in regions with similar climates. Growers in northwest Washington have reported removing 2% to 5% of trees each year and in some cases entire orchard blocks due to apple anthracnose canker. Research on apple anthracnose canker is limited and current apple anthracnose management recommendations are for Bull’s-eye rot on the fruit, not for the canker stage of the disease on trees. Thus, no effective control program exists for apple anthracnose canker. In western Washington infection appears to occur in late fall but disease progression ceases in the winter. In spring, the fungus resumes growth resulting in canker expansion and new infections may also occur. Cankers become fully mature by mid-spring (March–May), and in summer (–August) conidia are produced on the mature cankers and are dispersed by heavy rains and wind, causing new infections to surrounding trees and fruit. To better understand the epidemiology of this disease and the elements of an effective management plan, a controlled inoculation study was conducted in a screen house at Mount Vernon, WA. The treatments were designed to elucidate the necessity of wounding for infection and if Bordeaux mixture [copper sulfate (CuSO₄) and calcium hydroxide (Ca(OH)₂)] a common fungicide used in the orchards can prevent infection with or without wounding. The five treatments include: 1) Bordeaux mixture, wounding, inoculation; 2) Bordeaux mixture, no wounding, inoculation; 3) wounding, inoculation; 4) inoculation only; 5) control (no treatment). Treatments were applied 25 Nov. 2015, to two-year-old ‘Tompkins King’ apple trees, and after one month trees were observed every 2 weeks for symptom development. A canker was first observed 9 weeks after inoculation on, 27 Jan. 2016, in treatments 1 and 2. On 27 Feb., 13 weeks after inoculation, a canker appeared in all treatments excluding the control. Canker size ranged from 0.02 to 0.24 and infection occurred regardless of wounding and Bordeaux mixture. Small streaks of diseased tissue expanding from the wounded/inoculated area were observed only in treatment 3, suggesting that Bordeaux mixture may prevent disease progression when wounding occurs.

(257) Determination of Nutrient Requirements of Peach Trees from Different Ripening Seasons
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Peach trees are often fertilized without considering the amount of nutrients removed through practices such as pruning, thinning, harvesting and leaf fall. Furthermore, peach trees from different ripening seasons may have different nutrient requirements. The objective of this research was to determine the amount of nutrients removed in pruned wood, thinned fruit, harvested fruit and fallen leaves of peach trees from different ripening seasons. This information may be relevant for optimizing fertilization in peach orchards. 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 amount of nutrients removed at pruning, thinning, harvesting, and leaf fall. Nutrient analysis showed that early-season cultivars accumulated more nitrogen.
in thinned fruitlets and mature fruits, and more potassium in pruned wood and mature fruits than late-season cultivars. Fruit from late-season cultivars accumulated more calcium than early-season cultivars. Analyses of summer leaves revealed that all mineral concentrations were in sufficient levels but did not provide information on different nutritional needs of trees from different ripening seasons. These results suggest that peach trees of different ripening seasons may benefit of different fertilization programs rather than a universal fertilization program. Further research and more data are needed to evaluate the impact of different ripening season on peach nutrition but these findings are expected to help farmers to improve fertilization plans that are specific to the ripening season of their peach trees.

Specified Source(s) of Funding: South Carolina Peach Council

(258) Effect of Climate on Spring Phenology and Harvest Dates in ‘Fuji’ and ‘Hongro’ Apples in Korea
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Spring phenology and harvest dates of two apple cultivars, ‘Fuji’ and ‘Hongro’, were observed in 41 orchards across Korea for four years between 2011 and 2014. Climate data of each orchard were reconstructed by geostatistical methods on the basis of the network of weather stations and the digital elevation model. From the climate data, the WORLDCLIM bioclimatic variables (Bio 1 to Bio 19) were calculated to find a possibility as predictors. For spring phenology, dates of bud burst, flowering, and full bloom were compared to the climate data set from the previous year to the surveyed year. The monthly temperatures from the last October to April were related to the spring phenology without November in both cultivars. In a case of the bioclimatic variables, the mean temperature of driest quarter (Bio 9) and the mean temperature of coldest quarter (Bio 11) of the previous year were most related. Precipitation could not be found the relation to the spring phenology and harvest dates in both cultivars. Also, harvest dates could not be found any correlation to the climate data set in this study. From these results, we could make future flowering date maps with the scenarios of the RCP (Representative Concentration Pathways) 4.5 and 8.5.

Poster Session—Postharvest 3

(185) Changes in Quality of Astringent Persimmon during Ripening By Using an Ethylene-producing Tablet at Different Concentration and Temperature
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This study was conducted to evaluate the effect of ethylene on astringent persimmon at different concentration and application temperature. The varieties (Bansi and Daebong) used for the study were grown in Korea and harvested in November 2015. Ripening was done at 15 °C and 25 °C, with 80 ± 5% RH conditions using ethylene producing tablet for 6 days at 50 ppmv and 100ppmv concentration. The quality was examined every 2 days. Firmness in the case of ‘Bansi’ decreased from 14.8N to 3.5N at 15 °C ripening condition within 4 days while the control group were 11.2N. At 25 °C ripening, the firmness reduced fast to 3.6N within 2 days while the control group were 10.8N. In the case of ‘Daebong’ firmness after ripening at 15 °C was continuously reduced from 14.3N to 2.8N within 6 days but in the control group the softening proceeded slightly and the firmness was 11.2N. Similar trends were observed in case of treatments at 25 °C. Soluble solids content in case of ‘Bansi’ reduced as the ripening period proceeds from 18.6 °Brix to about 15 °Brix within 6 days. In case of ‘Daebong’ SSC reduced from 14.9 to 13.8 °Brix, there was no significant difference between the treatments and the control. Hunter ‘L’ values tended to decrease during the ripening period of both cultivars, showed a more reduced values in the treatment groups compared to the control. Hunter ‘a’ value in case of ‘Bansi’ was reduced from 23.0 to 16.2 and 10.5 in the control and treated groups, respectively, at 15 °C within 6 days. However, in case of 25 °C the value was increased slightly up to 2 days 26.1 and then reduced rapidly to 4.78. The higher the ethylene concentration the higher was reduction of Hunter ‘a’ value. In case of ‘Daebong’ at both 15 °C and 25 °C the change in Hunter ‘a’ value was similar. Soluble tannin content was 625 mg/100g immediately after harvesting in case of ‘Bansi’ and then in 15 °C condition, control group reduced to 529 mg/100 g within 6 days. However in the treatment groups, soluble tannin was reduced to about 335 mg/100 g regardless of ethylene concentration. In 25°C condition, in the treatment group, soluble tannin was reduced rapidly to 49 mg/100 g after 2 days. The control group reduced slightly to 528 mg/100 g within 6 days. Similar results were observed in ‘Daebong’. From the result, in both varieties, ripening quality was improved after 6 days at 15 °C and after 3–4 days at 25 °C regardless of ethylene concentration.
(186) Determination of Fruit Oil Content and Fatty Acid Composition in *Symplocos paniculata* Using Near-infrared Reflectance Spectroscopy

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*Symplocos paniculata* is an important a shrub or small tree with high fruit oil content that can be used as potential feedstocks for biodiesel and cooking oil production. The feasibility of using Near-Infrared Reflectance Spectroscopy (NIRS) at the wavelength range of 950–1650 nm for rapid and nondestructive determination of the fruit oil content and fatty acid composition of *S. paniculata* was investigated. Fruits were collected from 124 plants grown at different habitats in Hunan province. All fruits were air-dried and then scanned using NIRS. The fruit oil content and fatty acid composition were also analyzed using chemical method including hexane extraction and gas chromatography. The raw spectra were pretreated using four chemometrics such as 1st and 2st Derivative, Standard Normal Variate Transformation, Savitzky-Golay Smoothing, and Multiplicative Scatter Correction and then used for establishing calibration models. Partial Least Squares regression was used to develop the calibration equations for oil content and fatty acid composition. The coefficients of determination ($R^2$) and the calibration equations. The coefficients of determination ($R^2$) and the residual prediction deviations were 3.5, 2.9, 2.8, 3.1, 2.3, and 2.6, respectively. These results indicated that NIRS successfully predicted the oil content and determined the composition of palmitic acid, stearic acid, oleic acid, linoleic acid, and linolenic acid. In conclusion, the NIRS model has great potential in the nondestructive determination of the fruit oil content and fatty acid composition of *S. paniculata*.

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(187) Metabolic Profiles and Juice Quality Parameters of 14 USDA-ARS Pomegranate (*Punica granatum* L.) Cultivars As Determined By 1H NMR, Spectrophotometry, Ion Chromatography, and Refractometry

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Pomegranate (*Punica granatum* L.) juice is a highly valued beverage worldwide that has been demonstrated and marketed to have relatively large quantities of polyphenolic compounds with powerful antioxidant properties. The USDA-ARS National Clonal Germplasm Repository, Davis, CA, pomegranate collection conserves approximately 300 cultivars, many of which have yet to be evaluated for the food and beverage industries. The purpose of this work was to evaluate high, medium and low acid pomegranates using analytical chemistry methods to look for candidates that meet the metabolic and juice quality profiles of ‘Wonderful’ pomegranate juice. In this investigation, pomegranate juices from 14 different cultivars were analyzed using Nuclear Magnetic Resonance (NMR), spectrophotometry, ion chromatography and refractometry. The cultivars evaluated in this work included ‘Al Sirin Nar’, ‘Ambrosia’, ‘Blaze’, ‘Desertnyi’, ‘Eversweet’, ‘Golden Globe’, ‘Green Globe’, ‘Haku Botan’, ‘Loffani’, ‘Parfianka’, ‘Phoenixia,’ ‘Purple Heart’, ‘Sakerdze,’ and ‘Wonderful.’ This work represents the genotypic diversity of approximately 5% of the U.S. pomegranate germplasm and provides deep, previously unseen values regarding the nutritional and postharvest qualities of pomegranate juice from a diversity of cultivars. Metabolic and juice quality profiles were determined by analyzing for important juice quality parameters and metabolites, including concentrations of ethanol, glucose, fructose, citrate, malate, glutamate, glutamine, potassium, pH, total phenolics, antioxidant activity, titratable acidity and harvest index. There were significant differences among cultivars for most of the parameters. ‘Al Sirin Nar’, ‘Ambrosia’, ‘Blaze’, ‘Desertnyi’, ‘Eversweet’, ‘Purple Heart’, ‘Sakerdze’ and ‘Wonderful’ had significantly higher glucose mean concentration than ‘Haku Botan’, with 404.5, 409.4, 422.6, 385.8, 394.0, 379.8, 389.5, 417.1 and 301.6 mM, respectively. ‘Eversweet’ was the only cultivar that had a higher mean concentration of malate than citrate. Several candidate cultivars meeting ‘Wonderful’ postharvest juice quality specifications were identified.

Specified Source(s) of Funding: University of California and USDA-ARS
Florida fresh grapefruit production was valued at over $85 million in 2013-2014, and the Indian River (IR) production district is estimated to account for 70% of Florida’s grapefruit production. Huanglongbing (HLB) is a disease greatly affecting citrus production in Florida. The disease, caused by a phloem limited bacterium, results in phloem plugging, which disrupts carbohydrate translocation from leaves to roots and contributes to tree decline, increased fruit drop and eventually tree death. Foliar fertilization has been used by growers as a management strategy to improve tree health and maintain productivity of HLB-infected trees. While excessive potassium (K) levels in citrus tissue can result in fruit with thick peels, lower juice acidity, and cause poor color development, foliar application of K at post-bloom can significantly increase grapefruit size without negative side-effects. However, there is scant information available about effects of micronutrients on citrus fruit quality. The goal of this experiment was to evaluate the effect of foliar nutrition, applied throughout the growing season, on grapefruit quality at harvest and the development of decay and peel breakdown during subsequent storage. The study was conducted in two commercial red grapefruit groves near Fort Pierce, FL. Foliar fertilizer sprays were applied four times in 2014 and three times in 2015. Peel color, peel puncture resistance, juice percentage, Brix, and titratable acidity (TA) were evaluated for two consecutive seasons. Additionally, peel thickness was measured from one grove for the second season but was not affected by foliar fertilization. For both years, peel color, juice percentage, Brix, and acidity were not affected by foliar fertilization in either grove for both seasons. The only exception was in one grove during the second season where the application of fertilizer containing micronutrients, K and P, or DKP alone, resulted in significantly greater chroma (color intensity) than the control. For the first season, no significant differences were observed in percentage decay or peel disorders of fruit stored either at room temperature for up to six weeks, or after eight weeks at 10 °C and two weeks at room temperature. Fruit from the second year is still undergoing evaluation. Overall, supplemental foliar fertilization did not significantly affect fruit quality of these two red grapefruit cultivars for the first two years of the study.

**Postharvest Handling and Storage Quality of a New Mandarin Hybrid in Florida**

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A new, early season mandarin hybrid selection (designated ‘900’) that arose from a cross between ‘Robinson’ and ‘Fairchild’ tan-
gerine was released in 2011 and limited quantities of fruit were evaluated for postharvest quality and shelf life over seven harvests spanning four seasons. Quality attributes such as peel color, peel puncture resistance (PPR), total soluble solids (TSS), titratable acidity (TA), juice content, and the development of decay and peel disorders were evaluated before, during, and after storage at 4.5°C and compared to ‘Fallglo’ and ‘Robinson’ harvested at the same time. Compared to both ‘Fallglo’ and ‘Robinson’, fruit of ‘900’ had significantly deeper orange peel color (higher hue), lower TA, higher TSS:TA ratio, lower PPR, but similar TSS at harvest, and less decay after storage. After 6 weeks of storage, ‘900’ maintained 98% healthy fruit while ‘Fallglo’ and ‘Robinson’ maintained 76% and 65% healthy fruit, respectively. Although not significant, ‘900’ also tended to develop less peel disorders (2%) compared to ‘Fallglo’ (16%) and ‘Robinson’ (15%). Peel color of ‘900’ and ‘Fallglo’ did not significantly change with harvest year but, as expected, fruit developed significantly better peel color as each season progressed. Juice quality of ‘900’ did not significantly change relative to the same harvest dates or harvest period each year evaluated. However, juice quality of ‘Fallglo’ did significantly change as the harvest season progressed. Fruit juice quality of ‘Fallglo’ had significantly higher TSS, TSS:TA ratio and lower TA in late harvest season compared to early harvest season. Fruit juice content of ‘900’ and ‘Fallglo’ experienced a 5.1% and 7.4% increase, respectively, between the 2009-10 and 2010–11 seasons.

(191) Effects of a Hot Water or Heated Thiabendazole Dip on Postharvest Degreening of Citrus Fruit

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Postharvest degreening treatments are commonly used to improve citrus fruit peel color, especially early in the season. Nevertheless, peel color of degreened fruit is lighter than that of fruit with on-tree maturation. This practice also significantly enhances the incidence and severity of stem-end rot (SER) caused by Lasiodiplodia theobromae, an important postharvest disease of Florida citrus fruits. A postharvest fungicide drench before degreening is commonly used commercially to control this disease. To improve peel color of degreened citrus fruit and reduce the use of fungicides, this study evaluated the effects of a 2 min dip in heated water with or without thiabendazole (TBZ) on color changes, internal qualities, and SER development of citrus fruit. In 2015, ‘Fallglo’ tangerines were harvested on 12 October, navel oranges on 12 October, and grapefruit on 5 November and 3 December, all from groves near Fort Pierce, Florida. After harvest, fruits were immediately transferred to the packinghouse and received the following, 2-min dip treatments: un-dipped (dry control), water at 20°C (water control), TBZ (1000 mg·kg⁻¹) at 20°C, hot water alone at 52°C, TBZ (1000 mg·kg⁻¹) at 52°C, and TBZ (100 mg·kg⁻¹) at 52°C. All fruit were then degreened using 5 µL·L⁻¹ of ethylene at 29°C with 90% to 95% RH for 8 h (‘Fallglo’) or 48 h (navel and grapefruit), and then left for an additional 24-h “airing” time (without ethylene). The fruit were stored under ambient room conditions. Hot water treatments (with or without TBZ) accelerated peel color changes recorded as hue (H°), a* and a*/b* during storage, with the color turning deeper yellow earlier than fruit treated at 20°C. Previous research has shown that an additional 24-h “airing” time promotes further color change in ‘Fallglo’, but little additional color change occurs in navel or grapefruit, which was also observed in the current experiments. Grapefruit harvested in December demonstrated a greater response to the hot water treatments than fruit harvested in November. As expected, ethylene degreening accelerated the outbreak of SER of navel oranges and red grapefruit during storage, but 1000 mg·kg⁻¹ TBZ significantly controlled this disease, with hot water alone or hot water with a lower concentration of TBZ (100 mg·kg⁻¹) providing similar control effect. Neither TBZ nor hot water treatments had significant effects on fruit quality. The above hot water dip and fungicide treatments show promise for improving color development while reducing postharvest decay under Florida conditions.

(192) Effects of Blue or Red LED Light Irradiation on Postharvest Degreening of Citrus Fruit

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Postharvest degreening treatments with ethylene are commonly used to improve citrus fruit peel color, especially early in the season when declining field temperatures have not yet induced sufficient natural color development. Nevertheless, peel color of degreened fruit is lighter than that of fruit with on-tree maturation. To improve peel color of degreened citrus fruit, the present study evaluated the effects of combining ethylene exposure with red or blue light-emitting diodes (LEDs) on color changes and internal qualities of citrus fruit. In 2015, ‘Fallglo’ tangerines were harvested on 12 Oct., navel oranges on 12 October, and grapefruit on 5 Nov. and 3 Dec., all from groves near Fort Pierce, FL. Fruits were immersed into 1000 mg·L⁻¹ ethephon solution at 4.5 °C and compared to ‘Fallglo’ and ‘Robinson’ harvested at the same time. Compared to both ‘Fallglo’ and ‘Robinson’, fruit of ‘900’ had significantly deeper orange peel color (higher hue), lower TA, higher TSS:TA ratio, lower PPR, but similar TSS at harvest, and less decay after storage. After 6 weeks of storage, ‘900’ maintained 98% healthy fruit while ‘Fallglo’ and ‘Robinson’ maintained 76% and 65% healthy fruit, respectively. Although not significant, ‘900’ also tended to develop less peel disorders (2%) compared to ‘Fallglo’ (16%) and ‘Robinson’ (15%). Peel color of ‘900’ and ‘Fallglo’ did not significantly change with harvest year but, as expected, fruit developed significantly better peel color as each season progressed. Juice quality of ‘900’ did not significantly change relative to the same harvest dates or harvest period each year evaluated. However, juice quality of ‘Fallglo’ did significantly change as the harvest season progressed. Fruit juice quality of ‘Fallglo’ had significantly higher TSS, TSS:TA ratio and lower TA in late harvest season compared to early harvest season. Fruit juice content of ‘900’ and ‘Fallglo’ experienced a 5.1% and 7.4% increase, respectively, between the 2009-10 and 2010–11 seasons.

An asterisk (*) following a name indicates the presenting author.
for 1 minute, air dried, and then put in a growth chamber. The fruit were continuously treated at 29 °C for 10 h under 600 μmol·m⁻²·s⁻¹ red LED lights (650 nm), 400 μmol·m⁻²·s⁻¹ blue LED lights (465 nm), or in the dark (control). Another control consisted of fruit stored in dark at 20 °C. After the 10-h treatments, the fruit were stored under ambient room conditions for subsequent evaluations. The 29 °C blue and red LED light treatments significantly accelerate changes in hue (H°), chroma, lightness (L*), a*, b*, and a*/b*, resulting in better fruit flavedo color development during storage compared to the 20 °C control. When compared with the 29 °C control and red LED light treatments, the use of blue LED light significantly decreased peel H° and increased L*, a*, b*, a*/b* and chroma. Harvests of navel orange and grapefruit in November responded greater to the blue LED light than Fallglo and Grapefruit harvested in December. The light treatments had no effect on stem end rot caused by Lasiodiplodia theobromae or on internal quality (soluble solids, titratable acid, juice content, firmness, and weight loss). The results showed that blue or red LED light treatments improve color development of degreening citrus fruit, with blue LED light showing the most promise.

(193) Postharvest Evaluations of Avocado Fruit from Reciprocal Crosses of ‘Hass’ and ‘Bacon’

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California and Florida are the top avocado producing states, but grow avocados with different genetic backgrounds. California grows cultivars of Guatemalan and Mexican races, and their hybrids, while Florida grows cultivars of West Indian race and West Indian–Guatemalan hybrids that are more suited for humid, tropical climates. A population of California reciprocal crosses of ‘Hass’–‘Bacon’ hybrids was planted at the USDA-ARS, Fort Pierce, to find selections with good horticultural and postharvest quality traits well adapted to east-central Florida. This area of Florida experiences more freeze events than the current south Florida avocado production zone. Extensive phenotypic data on fruit quality (fruit weight, seed weight, fruit size and diameter, oil content, number of fruits per tree, dry matter, whole fruit firmness) was collected over the 2013–2015 growing seasons. Peel color was measured to find selections that turned darker upon ripening as the color change tends to mask minor surface imperfections. Upon ripening, all avocados exhibited a loss in green color expressed by lower b* values throughout all three years, and some appeared to become yellow-green with hue angle values close to 90. Edible and non-edible portions of the fruit were evaluated according to presence and absence of disorders. The highest mean severities in 2013 were observed in disorders such as uneven ripening, vascular browning, pink staining, and tissue breakdown. Uneven ripening and tissue breakdown had the highest mean severities in 2014 and seed cavity browning was the most common disorder in 2015. Fruit weight was highly variable, ranging between 96.8 and 418.3 grams. Fruit weight loss rate ranged between 0.14% and 0.71% per day over six days. Mean dry matter ranged from 15.5% to 34.4% (unripe) and from 14.5% to 36.0% (ripe) in 2013, from 17.4 to 35.3% (unripe) and from 13.2% to 29.6% (ripe) in 2014, from 12.7% to 29.9% (unripe) and 16.2% to 25.4% in 2015. In 2013, fruit had an average initial whole fruit firmness of 126 N and 144 N during two harvests and reached full ripe stage (20–30 N) between 12 and 16 days after harvest. In 2014 and 2015, initial average whole fruit firmness was 135 N and 136 N, respectively, and reached full ripeness within 10 to 14 days after harvest. Promising selections with potential as cultivars were identified with good horticultural traits and fruit quality.

(194) The Influence of Ripening Temperature on ‘Hass’ Fruit Quality

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Previous research demonstrated the importance of temperature management during avocado (Persea americana Mill) fruit ripening; however this work was focused on maintaining the fruit at elevated temperatures continuously during the ripening process. We examined the influence of short duration high temperature, as could occur during commercial ripening, on subsequent ‘Hass’ fruit quality. Fruit were held at various temperatures ranging from 18 °C to 35 °C for different durations in the presence or absence of ethylene following harvest and storage at 5 °C. Our results indicate that the most uniform fruit ripening occurs at 20 °C. We report on the influence of temperature, primarily on the incidence of fruit decay, uneven ripening and eating quality of ‘Hass’ avocado.
commercially available bell pepper (*Capsicum annuum* L.) cultivars with varying degrees of BS resistance were evaluated using a randomized complete-block design and 4 replications during Fall 2015 in Ft. Pierce. Investigators measured disease incidence, yield by fruit grade, and the following postharvest fruit characteristics: number of lobes, length, width, thickness, cracking, and bruising susceptibility. This trial was conducted on a commercial pepper farm using standard grower production practices for the region including seepage irrigation, fumigated plastic mulched beds, two rows of plants with nine-inch spacing between plants, and 18-inch spacing between rows resulting in a plant population equivalent to 19,360 plants/acre. Each plot consisted of 26 plants/replicate (13 plants/row). The above average temperatures and rainfall experienced during trial were conducive to disease development leading to widespread losses from bacterial soft rot caused by *Erwinia carotovora* and plant death from *Phytophthora capsici* and *Phytophthora parasitica*. Consequently only one harvest was conducted instead of the standard two. Of the cultivars evaluated, only ‘Rampart’ from Syngenta-Rogers and ‘3255’ from Seminis yielded super-jumbo fruit. Their average number of super-jumbo peppers per replicate was 66 and 48, respectively. Along with ‘SW001’ from Seedway, ‘3255’ was also an overall yield leading cultivar. The latter averaged 1,125 marketable fruit per plot and was found to be statistically equivalent to the 1105 produced by the former. The cultivar with the lowest marketable yield was ‘Bastille’ from Syngenta-Rogers with an average of 622 marketable peppers per replicate. With an average of 66 marketable fruit and plant death from *Phytophthora capsici* and *Phytophthora parasitica*. Consequently only one harvest was conducted instead of the standard two. Of the cultivars evaluated, only ‘Rampart’ from Syngenta-Rogers and ‘3255’ from Seminis yielded super-jumbo fruit. Their average number of super-jumbo peppers per replicate was 66 and 48, respectively. Along with ‘SW001’ from Seedway, ‘3255’ was also an overall yield leading cultivar. The latter averaged 1,125 marketable fruit per plot and was found to be statistically equivalent to the 1105 produced by the former. The cultivar with the lowest marketable yield was ‘Bastille’ from Syngenta-Rogers with an average of 622 marketable peppers per replicate. With a disease severity rating of 3.5, ‘Bastille’ was also the most susceptible cultivar to BS. Frequent rains and high humidity led to BS symptoms on 17% of the ‘Bastille’ plant canopy whereas the characteristic water-soaked necrotic lesions on all other cultivars ranged from 1.75% to 0.0% incidence. Cultivars in this low range were statistically equivalent and received a disease severity rating ranging from 0.63–0. The data generated by this trial provides useful information to aid in the selection of varieties for commercial pepper production in south Florida. However, the disease severity rating ranged from 0.63–0. The data generated by this trial provides useful information to aid in the selection of varieties for commercial pepper production in south Florida. However, these findings represent the results of one season’s growing conditions. The University of Florida/IFAS Extension recommends repeating the trial annually and encourages growers to take into account data collected from previous years due to weather and pest pressure variability.

**(351) Evaluation of Insecticides for the Management of Rough Sweetpotato Weevil, Blosyrus asellus (Coleoptera: Curculionidae) in Hawaii Island**

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Sweetpotato, *Ipomoea batatas* (Olivier), is an important staple food crop in Hawaii and critical to food security in these geographically isolated islands. Production of this crop faces a new challenge from the rough sweetpotato weevil (RSW), *Blosyrus asellus*, (Coleoptera: Curculionidae). We investigated efficacy of five insecticidal treatments that included four compounds (including one organic bioinsecticide) that were approved already for use against weevils in sweetpotato, plus a control (no insecticide treatment for RSW). Cuttings of sweetpotato cultivar Okinawan were planted on 1 April 2015, at Pepeekeo, Hawaii Island in a field with a history of past RSW infestation. Each plot contained 30 cuttings spaced 0.3 m apart in planting beds spaced 1.5 m apart and 9.1 m long. The five treatments were Belay 16 WSG (Clothianidin; Valen U.S.A. Corp., Walnut Creek, CA), Sevin XLR Plus (Carbaryl; Bayer CropScience, Research Triangle Park, NC), Provado 1.6 flowable insecticide (Imidacloprid; Bayer CropScience), Botanigard ES (*Beauveria bassiana* strain GHA; Laverlam International Corp., Butte, MT), and control. The five treatments were repeated four times in a randomized complete-block design. Harvesting of Okinawan sweetpotatoes was conducted at 4.5 months before most storage roots were marketable in size due to concerns about the duration of treatment effectiveness. Insecticidal treatments showed statistically significant differences (*P* < 0.01) in percent of all damaged tubers. Plots treated with Sevin or Belay had significantly lower percent of damaged tubers compared to the other three treatments. Each of these treatments appear to be effective in controlling RSW through 4.5 months after planting; however, the duration of the effectiveness of Belay is uncertain, since it was applied only once at planting. Perhaps, a combination of Belay application at planting followed by monthly applications of Sevin from 3 months after planting may be an effective method to control RSW. A second field trial has been installed to confirm these preliminary results.

**(352) Cultivar and Calcium Management to Minimize Lettuce Tipburn in Greenhouse Hydroponics**

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Tipburn injury is an important and serious abiotic disorder most likely associated with calcium deficiency. Tipburn can severely reduce the quality and marketing value of hydroponic lettuce (*Lactuca sativa* L.). This research was designed to screen eleven lettuce cultivars (Aerostar, Annapolis, Bibb, Coastal Star, Dragon, Fenberg, Green Forest, Holon, Outredgeous, Parris Island, and Sparx) for tipburn resistance. The influence of increasing calcium levels (187, 280, and 373 mg·L⁻¹) in reducing tipburn injury was further investigated. Lettuce seedlings were grown in greenhouse conditions under the nutrient film technique...
(353) Multi-year Yellow Squash and Zucchini Trials in Georgia

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Summer squash (zucchini and yellow) (Curcurbita pepo) is a significant crop for growers in Georgia. Valued at more than $50 million/annually, squash is grown during spring and fall seasons in Georgia. To ensure up to date recommendations are available to growers variety trials are routinely conducted in southwest Georgia in spring and fall seasons. In 2014 and 2015 variety trials were conducted including up to 20 varieties of yellow and zucchini squash. Plants were grown on raised beds with black plastic mulch and drip irrigation. Plants were spaced on 30 cm in-row spacing with 1.8 m between row spacing. In Spring and Fall 2014, ‘Gentry’ was the highest yielding variety, while ‘Solstice’ was the highest yielding variety in Spring and Fall 2015. ‘Gentry’ is a yellow crookneck variety, while ‘Solstice’ is a yellow straightneck variety. In Spring 2014 ‘SV6009YG’, was the highest yielding zucchini variety; however, in Fall 2014 and both seasons in 2015, ‘Respect’ was the highest yielding zucchini variety. In general those varieties with little or no virus resistance had the highest rates of cull fruit due to virus symptoms in the fall. Spine and vigor ratings were done as well. Varieties such as Spineless King and Spineless Beauty had the least spines, while the yellow straightneck variety Cosmos consistently had the most spines. This data will be used to inform growers and seed companies regarding performance of summer squash in Georgia.

Specified Source(s) of Funding: Georgia Vegetable Commodity Commission

(354) Results of the LSU Agcenter and Mississippi State University 2014 Fall Broccoli Variety Trial

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In the 2014 fall season, Louisiana State University AgCenter and Mississippi State University researchers evaluated twenty broccoli cultivars in two locations to determine which cultivars are best suited to Deep Southeastern environmental conditions. Cultivars were evaluated under conventional growing practices at Burden Botanical Gardens in Baton Rouge, Louisiana and the Coastal Research and Extension Center near Beaumont, Mississippi. ‘Packman’ was used as the standard cultivar because of its popularity among commercial producers. Cultivars were started from seed five weeks prior to transplanting at both locations. Cultivars were planted using drip irrigation and black plastic mulch. Rows were space 48 inches apart with plants double drilled at 12 inch centers. Pests were managed using recommendations in the 2014 SE Vegetable Growers Handbook. Heads were harvested at full maturity but before beads showed yellow color. Heads were categorized using USDA grading standards U.S. No.1 and U.S. No.2 and cull. Individual heads were weighed and counted. Stem and head width was recorded. Days to production were accounted for and disease and insect damage were noted. Cultivars were placed in the fields in a complete randomized design with three replications (twenty plants per replication) of each cultivar. Data were analyzed using Means Duncan’s PROC GLM. ‘Arcadia’, ‘Patron’, ‘Green Magic’ and ‘Everest’ out-produced ‘Packman’ in terms of total number of heads harvested/acre. ‘Bluewind’ and ‘Packman’ had 100% marketable heads, while ‘Arcadia’, ‘Everest’ and ‘Green Magic’ had 98%, 88% and 81%4 marketable heads, respectively.

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

(355) Evaluation of Carrot Cultivars for Production in Northern Climates

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Ten commercial cultivars (Baltimore, Bolero, Miami, Napoli, Negovia, Nelson, Romance, Scarlet Nantes, Touchon, Yaya) of carrot (Daucus carota) were evaluated for their growth, yield, and root quality for production in Northern Great Plains. Seeds were sown in the field on May 8 in 20-foot rows spaced 4 feet apart and seedlings were thinned to 1 inch apart between
plants in each row. Plants were grown without irrigation until roots were harvested on Oct 15. The yield was determined by
the weight of the roots harvested from 10-foot rows and per-
cent marketable roots. The soil type was the Fargo silty clay,
known for poor drainage. Out of 10 cultivars tested, Touchon
and Bolero produced greatest weight of roots at 22.8 kg and
21.7 kg, respectively, per 10 feet row on the average. The aver-
age root weight was highest in Miami (286.8 g), followed by
Bolero (226.8 g). Highest soluble solids contents of the root, as
determined by a refractometer, were found in Bolero (11.9%),
followed by Touchon (11.0%) and Scarlet Nantes (10.9%).
All of the cultivars evaluated produced a high percentage of
marketable carrots.

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

(356) Evaluation of Lettuce Cultivars for
Hydroponic Culture

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Sixty cultivars of lettuce were evaluated for their performance in
hydroponic culture. Seeds were germinated in Rockwool slabs
and seedlings at the two true-leaf stage were anchored 6 inch
apart on an NFT (nutrient film techniques) system. Plants were
grown for 4 weeks with a nutrient solution containing 200 ppm N
(prepared using 20–20–20 commercial analysis fertilizer). Plant
growth and quality were evaluated by fresh and dry weights,
plant size and shape, chlorophyll content (SPAD), soluble solids content (°Brix), pH, tissue nitrate (NO₃⁻), bolting, and
the presence of mold and leaf margin burns. The highest fresh
weight yield was obtained by ‘Giant Caesar’, followed ‘Ansar’,
‘Coastal Star’, ‘Vivian’, and ‘Rex Rz’. The total soluble solids content as measured by a refractometer was highest in 11C3487,
followed by ‘Caesar’s Favorite’, ‘Outrdegeous’, ‘Balfour’, and
3SX822. Tissue NO₃⁻ contents, which ranged from 4,000 ppm
to 30,000 ppm, were lowest in ‘Baby Romaine’ and ‘Aroyo’,
followed by ‘Aerostar’ and ‘Encino’. ‘Refugio’, ‘Red Oak’, and
‘Four Seasons’ had the highest tissue nitrate contents. Cultivars
with high propensity for bolting included ‘Black Seeded Simp-
son’, ‘Looseleaf Blend’, ‘Arctic Crisp’, ‘Simpson Elite’, and
‘Tango’. Cultivars with highest overall ratings were 11C3487,
Crunch’.

Specified Source(s) of Funding: NDDA-SCBG

(357) Evaluation of Tomato Cultivars for
Locally Grown Value-added Processing in North
Carolina

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North Carolina’s Food Processing and Manufacturing Initiative
aims to expand the underutilized workforce and maximize re-
sources within the state following the decline of other biomass
processing industries and the increased demand for locally
grown value added products. Tomatoes for processing have
been suggested, as they can be used for a salsa product brand
developed by a previously existing company. Currently this
product is largely made up of tomatoes from out of state, but
there is a strong desire to use locally sourced produce in the
manufacturing of this salsa. The objective of the study was to
evaluate processing tomato cultivars in diverse North Carolina
environments and determine their yield, quality and their suit-
ability to be used for salsa production. Ten cultivars (HMX2905,
HMX2906, HMX3881, HMX3882, HMX3888, HMX4909,
HMX7883, N6402, N6404, and SPESSO6415) were grown in
a randomized complete-block experimental design with three
replications. The trials were grown on three commercial tomato
grower’s farms and plants managed using standard commercial
practices on each farm. Among the three sites, marketable yield
ranged from 27.77 tons/acre to 2.45 tons/acre. N6402 and N6404
were consistently and statistically highest in marketable yield
among all three sites, where HMX3888 was consistently lowest
in yield. Blossom end rot was a problem at site 3. HMX4909
consistently fell within the desired range for pH, 3.60–4.40,
while HMX7883 consistently fell outside of the range. A 2% to
3% higher soluble solids content was found in tomatoes from
site 3 compared to the other sites. HMX2905 was consistently
in the top half for lycopene content, between 88.36 and 109.02
mg/kg. SPESSO6415 was consistently near the bottom, between
71.43 and 83.72 mg/kg. Although processing tomato production
in North Carolina is possible, production practices need to be
tailored in order to tomato maximize yield and quality.

Specified Source(s) of Funding: T.W. Garner and CALS Dean’s
Enrichment Grants Program

(358) Relative Salt Tolerance of 18 Chili Pepper
Cultivars

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Salt tolerance of 18 chili pepper cultivars (16 Capsicum annuum
cultivars and two Capsicum frutescens cultivars) was conducted
in a greenhouse experiment. Seedlings were grown in 4-inch
pots filled with Metro-mix 360 commercial substrates. During the one-month experimental period (12 Aug. to 12 Sept. 2013), seedlings were treated with nutrient solution (control) at electrical conductivity (EC) of 1.1 dS·m⁻¹ or saline solution at EC of 5.0 dS·m⁻¹ (salt treatment) for a total of seven times. All chili pepper plants did not experience any visible foliar salt damage (leaf edge burn, necrosis, or discoloration). However, salt treatment significantly decreased plant growth with large variations among cultivars. Plant height, leaf area, and shoot dry weight of 18 chili pepper cultivars reduced by 7% to 34%, 17% to 47%, and 13% to 39%, respectively. Hierarchical cluster analysis was conducted based on multivariate parameters including relative plant height, leaf area, and shoot dry weight. All chili pepper cultivars were clustered into three groups. Capsicum annuum ‘Keystone Resistant Giant’ and ‘New Mexico 6-4’ were the most tolerant cultivars to salinity. Capsicum annuum ‘Charleston Hot’, ‘Golden Bell’, ‘Hungarian Yellow Wax’, ‘Mesilla Cayenne’, ‘Mirasol’, ‘NuMex Centennial’, ‘NuMex Española Improved’, and Capsicum frutescens ‘Malagueta’ had intermediate salt tolerance, whereas Capsicum annuum ‘Barker’s Hot’, ‘California Wonder’, ‘Cayenne’, ‘Pimiento’, ‘Rio Grande’, ‘Sandia’, ‘Sonora’, and Capsicum frutescens ‘Tabasco’ were the most sensitive cultivars to salinity.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture Hatch project TEX090450

(359) Yield and Fruit Quality of Field-grown Grafted Tomato with Different Plant Spacings
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Plant spacing is a major production factor affecting tomato growth and yield as well as economic returns. As growth promotion and yield improvement are increasingly recognized as benefits of grafting it is important to determine the performance of grafted tomato plants in response to different planting densities. In this field experiment conducted at the University of Florida, Plant Science Research and Education Unit, Citra, FL, in Fall 2015, determinate tomato ‘Tribute’ was grafted onto three hybrid tomato rootstocks, including ‘Estamino’, ‘Multifort’, and ‘RST-04-106-T’, while non-grafted ‘Tribute’ was used as a control. Plants were grown in a fumigated field with five different in-row spacings (i.e., 0.46, 0.61, 0.76, 0.91, and 1.07 m). The experiment was arranged in a split plot design with four replications with spacing as the whole plot factor and grafting the subplot factor. Results showed that although the average fruit weight was not significantly affected by either grafting or spacing, marketable fruit number and weight per hectare were markedly impacted. Grafting with ‘RST-04-106-T’ and ‘Multifort’ resulted in significantly higher total marketable fruit weight as opposed to non-grafted plants, while plants grafted with ‘RST-04-106-T’ also had higher total marketable fruit number than all other treatments including the non-grafted control. Marketable fruit weight and number were significantly higher in plants grown at 0.46 and 0.61 m than that at 0.91 and 1.07 m. The regression analysis suggested that grafted plants especially those with ‘Multifort’ and ‘RST-04-106-T’ could be grown at wider spacing while maintaining/improving marketable yield in contrast to non-grafted plants. Neither grafting nor spacing showed any significant influence on tomato fruit soluble solids content, titratable acidity, and pH. Interestingly, ‘Tribute’ grafted onto ‘Estamino’ and ‘RST-04-106-T’ exhibited higher ascorbic acid concentrations as the in-row spacing increased, whereas the opposite trend was observed in tomatoes from the non-grafted plants and plants grafted with ‘Multifort’.

Grafting with ‘RST-04-106-T’ significantly increased fruit dry matter content as compared with non-grafted and other grafted plants. With respect to lycopene content, grafting resulted in significantly higher levels despite the rootstock cultivar used. Lycopene content at 0.46 m spacing was significantly lower than other spacing treatments. Grafting did not affect tomato total phenolic content but the 0.61 m spacing led to a significant increase in total phenolics of tomato fruit than the 0.46 and 1.07 m spacing treatments.

(360) Yield and Fruit Quality of Grafted Tomato Plants in Organically Managed High Tunnels Containing Zones with Different Compost Application Histories
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Documenting the performance of grafted plants under a wide range of conditions will allow many to benefit more reliably from grafting as an emerging technology in the United States. The goal of this research was to document grafted and ungrafted plant performance in organically-managed high tunnels containing zones with different compost application histories, using fruit yield and quality as primary indicators. Studies were conducted in 2012, 2013, and 2015 using a split-plot design with compost application history as the main plot and grafting combination as the subplot. Two compost treatments were included, one with annual compost application since 2003 and the other with no soil amendment since 2002. Two commercial rootstocks (‘Maxifort’ and ‘Emperador’) and one experimental line (‘338’) grafted to the same scion (‘Moskvich’) and ungrafted ‘Moskvich’ controls were employed in 2012 and 2013; two commercial rootstocks (‘Maxifort’ and ‘Estamino’) grafted to (‘BHN589’) and un-
grafted ‘BHN589’ controls were used in 2015. Ripe fruits were harvested weekly 8–9 times to measure weight and number of total fruit, marketable fruit, and fruit showing blotchy ripening, and a subset of fruits was analyzed for °Brix, pH, and titratable acidity (TA). Consistent yield trends were observed across the three years. Yield was greater in plots with a history of compost application and in plots containing grafted plants. Average marketable fruit weight was not different among grafting and compost treatments in 2012 and 2013, but it was larger for grafted versus ungrafted plants in 2015. Likewise, percent marketable yield was higher in compost-amended versus non-amended and grafted vs. ungrafted plots in 2013 and 2015, perhaps because compost application and grafting were associated with declines in the percent of fruit showing blotchy ripening in both years. However, Brix tended to be lower in fruit from grafted versus ungrafted plants across all years, while pH was higher in fruit from grafted vs. ungrafted plants in 2012 and 2015. TA was not affected by grafting, but it was higher with compost application in 2012. The compost-grafting interaction was not significant for most variables. We conclude that compost application and grafting can increase fruit marketable yield and alter some fruit traits, including °Brix and blotchy ripening. Grafted plants have a higher yield potential than ungrafted ones regardless of whether compost was applied to soils previously or not.

(361) Grafting English Cucumber Onto a Gourd Rootstock Improves Pot Cucumber Yield and Disease Resistance in Greenhouse
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Greenhouse production of high value vegetables from late fall to early spring provide farmers opportunity to target peak market prices and capitalize on the rising demand for locally grown produce. Low yield and disease problems are the main limiting factors for production during this period. This study focuses on evaluating grafted cucumber (grown in pots) as a potential high value crop, thus improving greenhouse output. We tested the grafting of cucumber scions onto a selected gourd (Lagenaria siceraria) rootstock for yield improvement and disease resistance. The results showed that grafted plants produce more fruits than the non-grafted control. Grafted Camilla plants yielded more fruits per plant (4.6 lb) than non-grafted plants; additionally grafted plants showed improved disease resistance. Grafted fruit taste is comparable to the non-grafted control. This research helps to prove that specific gourds can be a good rootstock candidate for off-season cucumber production in greenhouses by improving output per square feet.

(362) Effect of Fertilizer Source and Grafting on Quality of High Tunnel-grown Tomato
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Tomato is a major vegetable crop worldwide, and is grown in high tunnels in most regions. This study compared two fertilizer sources and the use of grafted plants on the quality of tomato fruit grown in high tunnels in northwest Washington in 2015. The two fertilizer sources were commercial conventional fertilizer [monoaonmum phosphate (11–52–0), potassium sulfate (0–0–50), and urea (46–0–0)] applied at 112 N, 168 P2O5, and 56 K2O kg·ha−1, and an integrated fertility treatment [poultry manure (2242 kg·ha−1) plus 90 kg·ha−1 urea (46–0–0)] where poultry manure application was limited by P content. The experimental design was a split plot where the main plot treatment was fertilizer and the subplot treatment was grafting: ‘Panzer’ grafted on ‘Estamino’, Maxifort’, ‘DRO138TX’, and non-grafted ‘Panzer’ (control). Fruit were harvested once a week, when fruit reached the 75% red stage, and the quality of marketable fruit were evaluated for juice content, fruit firmness, soluble solid content (SSC), pH and titratable acidity. There were no significant differences due to fertilizer source on any of fruit quality parameters measured in this study. Overall mean juice content was 93.4% for both the commercial and the integrated fertility treatments. Overall mean firmness of tomato fruit was 2.5 N for commercial fertilizer and 2.4 N for the integrated fertility treatment. Overall mean SCC (°Brix) of tomato fruit was 5.1, and overall mean pH was 4.3 for both fertilizer treatments, while overall mean titratable acidity (% CA eq.) was 0.36 and 0.33 for the commercial and integrated fertilizer treatments, respectively. On the other hand, fruit from grafted plants had higher juice content than non-grafted plants on 10 and 17 Aug. (93.6% and 93.2% overall average, respectively). Additionally, fruit from plants grafted with ‘Estamino’ rootstock had a higher pH on 10 Aug. than other grafting treatments (4.4 and 4.3, respectively). There were no differences in fruit firmness, SSC, or titratable acidity due to grafting.

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(363) Increasing Survival of Grafted Watermelon Transplants
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Although grafting holds promise as a soilborne disease management strategy for watermelon production in Washington, it currently has significant limitations. Increased production costs related to grafting include the skilled labor needed for grafting, the special facilities that are required for the proper healing of the grafted plants, and unpredictable survival rate of grafted watermelon transplants. Studies with grafted tomato showed 98% survival by using a low cost healing chamber but watermelon
graft survival was 80% as a result of the particular grafting technique (one-cotyledon splice) and the susceptibility of the plant to desiccation following the grafting procedure. The graft union for watermelon tends to be slow to heal (7–9 days) and the plant must rely on moisture in the air for survival during this time period. In 2015, a greenhouse experiment was conducted to investigate if application of commercial antitranspirant products (Moisturin film-forming, and Root-Zone stomata-closing), could increase the survival of grafted watermelon transplants. The one-cotyledon grafting method was used for grafting watermelon (cv. TriX Palomar) with rootstock (cv. Emphasis). The study utilized a randomized complete-block design with 4 treatments and 5 replications, 12 plants per experimental unit, and was repeated two times. The treatments were applied one day before grafting: Moisturin (10% solution), Root-Zone (1.56% solution), Moisturin & Root-Zone (applied at the same respective rates), and a water control. The survival rate of grafted watermelon differed due to antitranspirants treatments ($P < 0.0001$). The treatment Moisturin + Root-Zone had the greatest survival rate (96%) while the Moisturin application had the lowest survival rate (55%), and Root-Zone treatment and water control had 88% and 73% survival rate, respectively. Results from this study indicate that survival rate of grafted watermelon transplants can be increased by using a combination of commercial antitranspirant products, Moisturin + Root-Zone, or application of Root-Zone only one day before grafting.

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Poster Session—Waste Utilization in Horticulture

(241) Effect of Plant Species on Nitrogen and Phosphorus Removal in Aquaponic System

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Aquaponics is a hybrid production system that integrates aquaculture with hydroponics to grow various crops with fish wastewater in a recirculating system. A well-managed aquaponics can improve nutrient retention efficiency, reduce water usage and waste discharge to the environment, and enhance profitability by simultaneously producing two cash crops. By practicing aquaponics systems in non-traditional locations for agriculture or on marginal lands, aquaponics can function as a sustainable model for food production. Although different types of crops have been tested in aquaponics, the selection of plant species has relied mainly on experience. Nitrogen (N) and phosphorus (P) are major nutrients available in aquaculture effluents causing environmental issues. Thus, improving nutrient use efficiency through proper crop choice is a critical task for better performance of aquaponics system. Since different plants have different growth characteristics, different cultural strategies need to be developed to achieve the best production efficiency. However, limited studies have been conducted to systematically investigate the effect of plant species on the performance of an aquaponic system. The objective of our research was to evaluate the effect of plant species on N and P removal in aquaponics system in order to improve nutrient recovery by utilizing aquaculture effluents as sustainable mineral nutrient sources for vegetable production. Three vegetable crops (lettuce, basil, and tomato) were separately grown in aquaponic systems. Water quality parameters were monitored daily and N and P concentrations were measured every other day. The results showed that plants effectively removed N and P during their production cycle with increasing removal rate as their biomass increased. Although there were no significant ($P > 0.05$) differences in daily removal efficiency among plant species when the plants were young, tomato showed significantly ($P < 0.05$) higher N removal rate compared to other plant species as they grew mature. However, N accumulated over time in aquaponics systems while P level was maintained throughout production period. Our results indicate that N and P removal efficiencies are varied by plant species and production stage. It is concluded that, in combination with proper crop choice, reducing N and P inputs in the system is critical to effectively manage aquaponic system.

(242) Growth and Yield Comparison of Lettuce, Basil, and Tomato Grown in Aquaponic and Hydroponic Systems

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Aquaponics is a production system that integrates aquaculture and hydroponics by recirculating residual nutrients resulted from fish waste for cop production. Although many different crops have been tested in aquaponics systems, limited information is available on the growth and yield of a crop grown in aquaponics compared to hydroponics. The objective of our research was to evaluate growth and yield of vegetable crops grown in aquaponics in comparison to hydroponics. Two leafy vegetables, lettuce (Lactuca sativa) and basil (Ocimum basilicum), and one fruity vegetable, cherry tomato (Solanum lycopersicum), were grown in both aquaponics and hydroponics systems. Each aquaponic unit consisted of a 378L fish tank with stocking density of 26 kg/m³ Nile tilapia (Oreochromis niloticus L.) and a 378L growth bed with vegetable crops at the recommended planting density. The pH was monitored daily and adjusted to target levels (pH 7 in aquaponics and pH 6 in hydroponics). Measured EC averaged at 0.7 dS/cm in aquaponics while it was maintained at 2.0 dS/cm in hydroponics. The growth, yield, SPAD values and other morphological parameters were assessed during a 5-month production period. The results showed that marketable yield of hydroponically grown lettuce was significantly higher ($P < 0.05$) compared to aquaponically grown one, while there

An asterisk (*) following a name indicates the presenting author.
were no significant differences in marketable yields of basil and tomato grown in both systems. Interestingly, aquaponic tomato produced significantly lower ($P < 0.05$) fresh weight of stem and leaves but larger roots compared to hydroponic tomato, indicating that limited nutrients in aquaponics reduced shoot growth without affecting yield of tomato fruits. The SPAD values were higher in aquaponically grown vegetables although leaf parameters were not significantly different from hydroponically grown ones. It is concluded that the growth and yield of different vegetable crops are differently affected by production system, and therefore, a careful consideration is needed in determining vegetable crops suitable for the production in aquaponics system.

### Poster Session—Water Utilization and Management

**[381] Economic and Cultural Effects of Reducing Substrate Moisture Content during Greenhouse Production of Bedding Plants**

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Retail environments are rarely optimum for ornamental plants, and wilting caused by water stress is a main cause of post-production shrinkage. The objective of this research was to determine if withholding water during greenhouse production would increase plant tolerance to postharvest water stress. Our hypothesis was that withholding water during greenhouse production would increase plant tolerance to post-production water stress without a significant reduction in visual quality of the plant. If the hypothesis was correct, then the cost of production and the amount of water required would be reduced. This experiment was conducted in a greenhouse, using two substrate moisture (SMC) levels: 20% and 40%, and 10 replications for each SMC treatment. Two plants species were tested: angelonia (*Angelonia angustifolia* ‘Angelfast Blue’), and heliotrope (*Heliotropium arborescens* ‘Simply Scentsational’). During eight weeks of greenhouse production, plants were hand watered to container capacity after reaching the treatment moisture level and allowed to dry down again several times from plant establishment until plants were deemed marketable. Weekly data collection during production included plant growth index (GI); leaf greenness index (SPAD); substrate leachate electrical conductivity (EC) and pH; plant net photosynthetic rate (A); and midday water potential ($\psi$). At the stage when the plants were deemed to be marketable based on industry standards, plants went through a simulated shipping process in the dark for 48h followed by two weeks of simulated shelf life, during which plants were watered when wilting began to occur. Timing of all cultural and labor inputs during production and postproduction were recorded for partial budgeting economic analysis. At termination of production and shelf life, data collection included: total inflorescence number; plant and flower dry weight; root to shoot ratio; SPAD; water-use efficiency; and middle day water potential. During production, angelonia grown at 40% SMC had higher GI and A than those grown at 20% SMC in week 7 and 8. Both angelonia and heliotrope grown at 40% SMC had higher SPAD readings than those at 20% SMC in week 5 and 6, conversely, in week 7 and 8, plants grown at 20% SMC had higher SPAD readings.

*Specified Source(s) of Funding:* USDA Floriculture and Nursery Research Initiative

**[382] Comparing Stomatal Conductance of Street Tree Species in Traditional Tree Pits and Green Infrastructure Storm Water Trenches**

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Urban combined sewer systems (CSS) such as that of Philadelphia can lead to combined sewer overflows (CSO) during intense storm events. The CSO generate serious environmental concern due to their introduction of untreated waste into local waters. Philadelphia’s Green City, Clean Waters initiative calls for significant implementations of green infrastructure in order to control the amount of storm water runoff entering the sewer system. One such structure is a storm water tree trench, which consists of soil-filled tree pits installed on top of a large gravel-filled catchment area beneath the sidewalk. Storm water, collected through curbside inlets, is distributed through the catchment area via a perforated pipe. The trenches are designed to retain large volumes of water, with a portion eventually percolating into the soil below, and some being accessed and transpired by the trees above. In order to assess the effectiveness of the storm water trenches in controlling CSO, it is necessary to evaluate the water relations of the various associated tree species. Stomatal conductance measures the concentration of water vapor released from tree leaves, and thus it serves as an excellent proxy for total evapotranspiration as well as water stress. The stomatal conductance of 25 trees of 13 different species/cultivars located on two blocks in the Mt. Airy section of Philadelphia was monitored from June–October 2015. In assessing 25 different trees, the mean ranks of conductance data by species were significantly different, suggesting some species may be better suited for use in urban GI trench trees than others. Two potential benefits of these species are 1) they have higher overall levels of conductance resulting in greater water movement out of the system via evapotranspiration following rain events, and 2) they may be less susceptible to water stress during periods of low precipitation. Furthermore, an asterisk (*) following a name indicates the presenting author.

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pairwise comparisons revealed that Koelreuteria paniculata Laxm. and Prunus sargentii Rehder trees conducted significantly more water on average within storm water trenches compared to traditional, isolated tree pits, whereas Quercus macrocarpa Michx. and Quercus robur L. showed the opposite tendency. This research provides useful insight for further development of storm water tree trenches by showing that tree species selection can influence the effectiveness of the system.

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(383) Water Relations of Trees Growing in a Green Infrastructure (GI) Storm Water Trench

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Storm water management is a major concern for cities with outdated combined sewer systems. Uncontrolled storm water pollutes urban watersheds, and impairs the ecological function of streams and rivers. Storm water interception using urban green infrastructure (GI) installations planted with street trees will be a major contributor to improving overall runoff control. It is important to assess the performance of these trees to better understand their contributions to storm water management. This research project focuses on water relations of trees in a GI tree trench system in the Mt. Airy section of Philadelphia. Acer rubrum ‘Armstrong’ and Platanus xacerifolia ‘Bloodgood’ were evaluated nearly daily at peak solar radiation from May through November for stomatal conductance (g_s), leaf water potential (Ψ_p) and leaf area index (LAI). Using Ψ_p and g_s data from healthy specimens of similar age, the overall water stress of trees in these systems could be quantified. Water relation trends were evident, and analysis showed a significant difference between stomatal conductance rates of the two species, but not within species. Analysis of Ψ_p data showed significant differences between the ranked data of the two species. In general, through the entire growing season, P. xacerifolia had greater stomatal conductance and lower susceptibility to water stress than A. rubrum ‘Armstrong’. These results suggest P. xacerifolia performs more successfully in these systems when compared to A. rubrum. These results could possibly be influenced by overall plant health, and species traits such as root structure (access to available water), and other traits that affect water relations. This study provides some fundamental data on water relations and species performance in a GI tree trench system. With the increase of GI systems, continued research in plant performance is essential in developing successful stormwater management systems. Further research plans include assessment of performance throughout the entire course of a day, both seasonally and in consecutive days following significant rain events, determining overall evapotranspiration rates, and assessments of other species and GI systems.

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

(384) Alternative Irrigation Scheduling: Comparing the Smartirrigation App to Checkbook, and Soil Moisture-based Irrigation Methods for Watermelon

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Numerous tools have been developed to improve irrigation scheduling in vegetables. However, growers have been reluctant to adopt these irrigation scheduling methods because they may be too cumbersome or to use, require specialized equipment, or are perceived to be risky compared to traditional methods. Recently, smartphone applications have been developed that schedule irrigation based on crop coefficients and real-time weather data. Called the Smartirrigation™ application (smartirrigationapps.org), these tools have the potential to aid farmers in conserving water and nutrients for crops. The parameters to determine irrigation in each application are based on crop-specific evapotranspiration (Et) curves that have been linked to weather stations in Georgia and Florida. One difference in the new application compared to previous methods of determining irrigation based on Et is that the new model has the ability to use weather forecasting tools to predict Et for several days in advance, allowing irrigation to be scheduled proactively. To determine the efficacy of the new Smartirrigation application for watermelon, a trial was conducted comparing it to automated soil moisture based irrigation (tensiometers) and water-balance methods. Watermelon ‘Melody’ was planted into raised beds of black plastic mulch. The trial was a randomized complete block design with four replications of each treatment. Total water use, soil moisture at depths of 15, 25, and 36 cm, as well as yield, soluble solids, and hollow heart incidence were recorded. Data from this trial will be used to demonstrate the overall utility of the Smartirrigation application for vegetable growers.

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

(385) Effects of Maintained Substrate Gravimetric Water Content from Transplant to Finished Stage on Impatiens walleriana ‘Xtreme Red’

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Growers differ on the ideal substrate moisture content for bedding plants immediately following transplanting. In this experiment, Fafard 3B was maintained at five gravimetric water content (GWC) levels to determine effects on Impatiens xwalleriana shoot and root growth as well as depth of root growth within the substrate profile. Plugs were potted into 15 cm containers and irrigated initially to 64%, 68%, 72%, 76%, or 80% GWC. Plants were irrigated by hand daily using a 60 mL syringe to bring it to its target GWC. The experimental design was a completely randomized block. Substrate pH and EC were collected three and six weeks after potting (WAP) while size indices were collected weekly. At six WAP, shoots were harvested, and containers were brought back to container capacity and placed in a freezer at −2 °C. After freezing, root balls were divided in half using a machete and rubber mallet. An increase in GWC resulted in an increase in size index, shoot dry weight, and root dry weight. There was a moderate increase in size index between 64% and 76% target GWC (9.6%) and a substantial increase between 76% and 80% target GWC (24.2%). Irrigation volume increased substantially between 64% and 76% target GWC (33%) and increased moderately between 76% and 80% target GWC (29%). Substrate maintained at 80% GWC resulted in the highest percentage of roots in the bottom half of the substrate profile. Results may differ in finer textured substrates that have less air space.
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Monday, August 8, 2016

**Special Session—Using Technology in Extension: Technology Session for Extension Agents**

Coordinator: Susan Barton  
University of Delaware, Cooperative Extension Service, Townsend Hall, Newark, DE 197171303

9:00–9:30 AM

**Driving Your Technology Decisions with Educational Best Practice**

Emily Barton*  
University of Virginia, Charlottesville, VA

Technology can redefine professional learning opportunities, but it is an instructional tool that needs to be thoughtfully implemented. Educational theory offers actionable guidelines for best practice to evaluate the fit of digital technology for different instructional modes, learner populations, and organizational contexts.

9:30–10:00 AM

**Helping the Green Industry Navigate the Challenge of Social Media**

Cheryl R. Boyer*  
Kansas State University, Manhattan, KS

Our recent research indicates that small, local green industry businesses (garden centers, nurseries, lawn care firms, etc.) are often overwhelmed and underprepared to respond to the changing face of online marketing. We created a new resource, The Center for Rural Enterprise Engagement to assist owner/operators with learning to maximize marketing efforts and grow their businesses.

10:00–10:30 AM

**From 0 to 1000 Followers: Building a Social Media Presence in the Green Industry**

Jared Hoyle*  
Kansas State University, Manhattan, KS

Social media is becoming more than just social; it is becoming the most popular source for news and information. Therefore, there is a need to utilize social media outlets to disseminate research-based information. Learn how to create a social media presence in the horticulture industry.

10:30–10:45 AM

**Break**

10:45–11:15 AM

**Increasing Engagement Using Digital Communication Technologies**

Eric Stafne*  
Mississippi State University Coastal Research & Extension Center, Poplarville, MS

Digital communication technologies (aka Social Media) have become an integral part of Extension-client interaction. Technologies, such as macro- and micro-blogs, allow Extension personnel to substantially increase engagement with online information consumers and ultimately help to fulfill Extension’s mission of extending knowledge and changing lives.

11:15–11:45 AM

**Modern Communication, Effective Extension, and Technology-limiting Cultures**

Judson Reid*  
Cornell Cooperative Extension, Penn Yan, NY

New York has the fastest growing Old Order Amish population of any state. Evaluation work conducted by the Cornell Vegetable Program indicates that these groups prefer personalized extension resources. How do we stay current with social media and relevant to these and other unique, technology-limiting cultures?

11:45 AM–12:15 PM

**# Extension**

James T. Brosnan*  
University of Tennessee, TN

From basic mechanics to tracking impressions and engagement, this presentation will discuss how to effectively use Twitter in Extension programming.

12:15–12:45 PM

**Engaging the Millennial Generation**

Elizabeth Barton*  
University of Maryland, College Park, MD

As Millennials age into home and business ownership, horticultural organizations need to engage this digitally native generation. Why are newer technologies and social media so...
effective with Millennials? How can we use this information to deliver content and to effect change? One potential method is podcasting, a form of episodic audio content. Podcasting can give horticulture a voice, tell stories and speak to younger audiences in a language they understand.

Wednesday, August 10, 2016

Special Session—Career Development Tool—Gaining International Presence for Promotion and Tenure

Moderator: John Dole
North Carolina State University, 158 Kilgore Hall, Raleigh, NC 27695-7609

Coordinator: Mathieu Ngouajio*
USDA-NIFA, 800 9th Street SW, Washington, DC 20024

1:45–2:00 PM

University Administration Perspective on International Activities for Promotion and Tenure

John Dole*
North Carolina State University, Raleigh, NC

2:00–2:15 PM

Spend Just a Few Weeks—Gain Valuable International Experience

John L. Griffis*
Sidney R. Davis Chair for Horticultural Education & Research, Florida Gulf Coast University, Ft Myers, FL

Many would like to incorporate international experiences into their resumes, but they aren’t quite sure how to go about getting any. Without previous consulting experience, it is almost impossible to get a paid international consulting position. The Peace Corps sounds good (and it is), but that takes more than a two-year commitment. Those traditional Fulbright Scholar awards are prestigious, but they can take up anything from 5–10 months of time—time many do not have or cannot manage to arrange with a busy schedule. So how does someone get international experience and make international connections quickly? Well, the connections can often come at international conferences—there are often local scientists who would like to connect to a U.S. academic. Presentations at international conferences are good for the resume, too. However, there are several other short-term ways to gain valuable international experience. One available route is as a volunteer expert on a USAID-funded project. Many of these take only two weeks, occur in many different countries, and provide the volunteer with valuable field experience and opportunities to make connections. Another great way to gain international exposure is to become a Fulbright Specialist. This program involves just a two to six week commitment overseas and makes you a “Fulbrighter”—that always looks great on the resume. The “ins and outs” of these two short-term possibilities will be discussed.

2:15–2:45 PM

Opportunities for Global Engagement through USDA/NIFA Programs

Otto Gonzalez*
Director, Center for International Programs, National Institute of Food and Agriculture

The National Institute of Food and Agriculture (NIFA) grant programs provide support to U.S. institutions to advance agricultural research, education, and extension to solve societal challenges. Although NIFA makes these investments to achieve domestic objectives, in an increasingly interconnected world, to efficiently solve problems in the United States we may need information and cooperation from beyond our borders. Also, solutions we find for problems in the United States may be useful in other parts of the world. The National Institute of Food and Agriculture is developing partnerships with international and foreign institutions who can align their investments with NIFA to provide opportunities for NIFA-funded researchers to have partners from other countries in order to have greater impacts. The Agriculture and Food Research Initiative (AFRI) includes options for international collaboration as do several other NIFA grant programs. Some of NIFA’s grant programs that enhance a U.S. institution’s educational capacity include student experiential learning components for which international experiences can be an option. These different opportunities for global engagement through NIFA’s programs will be discussed, along with any questions from session participants.

2:45–3:00 PM

Developing International Recognition in Horticulture

Elizabeth Mitcham*
University of California, Davis, CA

Advancement to the higher ranks at many institutions requires evidence of an international reputation. But how can you build this reputation? There are many routes that can be taken. Some of the most fruitful strategies include making an effort to get acquainted with colleagues from other countries at ASHS and ISHS conferences. This can lead to opportunities to host international colleagues and their students in your lab/university and establish research collaborations. There is frequently a lot of interest in these opportunities, as an internship abroad is a requirement at many universities. You can also accept graduate students into your lab from other countries. The relationships built through mentoring a graduate student can last a lifetime. Try to visit your student in their home country after they go home. You can also agree to serve on the dissertation commit-
An asterisk (*) following a name indicates the presenting author.
APPENDIX

Appendix: Presentations Listed by Title
(Includes Colloquia, Workshops, Oral, and Poster Presentations)

Part 1. Colloquium, Special Symposium, and Workshops Presentation

Colloquium
Farms of the Future: Controlled Environment Agriculture

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Controlled Environments for Production of Value-added Food Crops and Transplants ............. S62
Improving Efficiency, Reducing Risk: Making Sense of Uncontrolled Environments ............... S62
Thinking Sociologically about Controlled Environment Agriculture: Challenges and Opportunities S62
Discussion ..................................................................... S62

Special Symposium
Mysteries of the Voynich Codex: A Mesoamerican Herbal

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