Understanding Sprayer Nozzle Technology and Pesticide Drift

Reducing the potential for pesticide drift

DAVE NICOLAI, EXTENSION EDUCATOR - CROPS

FIRST WE NEED TO UNDERSTAND MORE ABOUT SPRAY DROPLETS

- Particles or Droplets are what makes up the spray pattern from the nozzle.
- Droplet size directly impacts efficacy and drift.
- Droplet size is expressed in Microns (micrometers). One micron is approximately 1/25,000 of an inch

COMPARISON OF MICRON \( \mu \text{m} \) SIZES (APPROXIMATE) OF SPRAY DROPLETS

- 2000\( \mu \text{m} \) - #2 Pencil lead
- 850\( \mu \text{m} \) - paper clip
- 420\( \mu \text{m} \) - staple
- 300\( \mu \text{m} \) - toothbrush bristle
- 150\( \mu \text{m} \) - sewing thread
- 100\( \mu \text{m} \) - human hair

*150-200 micron droplets are considered highly driftable

Droplet Size Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Symbol</th>
<th>Color Code</th>
<th>Approximate VMD or Volume Median Diameter in microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Fine</td>
<td>XF</td>
<td>Purple</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Very Fine</td>
<td>VF</td>
<td>Red</td>
<td>&lt;136</td>
</tr>
<tr>
<td>Fine</td>
<td>F</td>
<td>Orange</td>
<td>136-177</td>
</tr>
<tr>
<td>Medium</td>
<td>M</td>
<td>Yellow</td>
<td>177-218</td>
</tr>
<tr>
<td>Coarse</td>
<td>C</td>
<td>Blue</td>
<td>218-349</td>
</tr>
<tr>
<td>Very Coarse</td>
<td>VC</td>
<td>Green</td>
<td>349-428</td>
</tr>
<tr>
<td>Extremely Coarse</td>
<td>XC</td>
<td>White</td>
<td>428-622</td>
</tr>
<tr>
<td>Ultra Coarse</td>
<td>UC</td>
<td>Black</td>
<td>&gt;622</td>
</tr>
</tbody>
</table>

*Data extracted from American Society of Agricultural and Biological Engineers (ASABE) Standard S-572.1.

DRIFT DYNAMICS

- Gravity and air resistance influence the speed and movement of spray droplets
- Gravity and air resistance influence the speed and movement of spray droplets
- Small droplets evaporate quickly, leaving minute particles in the air.
- The longer the droplet is airborne, the greater the potential for drift.

CONSIDER THE TYPES OF DRIFT THAT MAY OCCUR:

- Particle Drift most important - movement of spray particles during or after the spray application due to wind, boom height, temperature inversions etc.
- Vapor Drift - associated with volatilization (gas, fumes) of the product itself.
PARTICLE DRIFT – BIG 4

1. Wind Speed
2. Boom Height

BOOM HEIGHT

When the boom height was increased from 18 to 36 inches, the amount of drift increased 350% at 90 feet downwind.

350% Increase 90 ft.
PARTICLE DRIFT – BIG 4

1. Wind Speed
2. Boom Height
3. Distance from Susceptible Vegetation
4. Spray Particle Size

DISTANCE DOWNWIND
If the distance downwind is doubled, the amount of drift decreases five-fold. If the distance downwind increases from 100 to 200 feet, you have only 20% as much drift at 200 feet as at 100 feet.

DROPSIZE FACTS:
- One micron = 1/25,000 inch
- Expressed as Volume Median Diameter (VMD)
- Droplet Spectrum - Typically ranges - big to small
- Example - VMD = 500 microns
- % Volume in droplets less than 200 microns in size

EVAPORATION OF DROPLETS:

Inversions:
Under normal conditions air tends to rise and mix with the air above. Droplets will disperse and will usually not cause problems.
TEMPERATURE INVERSIONS:

Under these conditions the temperature increases as you move upward. This prevents air from mixing with the air above it. This causes small suspended droplets to form a concentrated cloud which can move in unpredictable directions.

Recognizing Inversions:

• Under clear to partly cloudy skies and light winds, a surface inversion can form as the sun sets.
• Under these conditions, a surface inversion will continue into the morning until the sun begins to heat the ground.

Strategies to Reduce Drift:

- Select nozzle to increase drop size
- Increase flow rates - higher application volumes
- Use lower pressures
- Use lower spray (boom) heights
- Avoid adverse weather conditions
- Consider using buffer zones
- Consider using new technologies:
  - drift reduction nozzles
  - drift reduction additives
  - Shields, hoods

Herbicide Classification

• Herbicides can also be classified as contact or systemic. **Contact** herbicides kill only the part of the plant on which they are sprayed. The root system is not killed and the weed may grow back from the roots. **Systemic or Translocated** herbicides are absorbed by the plants and taken into the root system, so the whole plant can be killed.

CONTACT VS SYSTEMIC DIFFERENCES

<table>
<thead>
<tr>
<th>Contact</th>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requires Good Coverage - Smaller Droplets</td>
<td>Drift Reduction - Larger Droplets</td>
</tr>
</tbody>
</table>

All spray applications should not use the same nozzle

Nozzles Types and Droplet Size Output

• At a given pressure, a nozzle will produce a range of droplet sizes. However, manufacturers strive to design nozzles with uniform outputs while reducing the number of "fines" a nozzle produces.
• Nozzles are rated based on the typical droplet-size range they produce.
NOZZLE SELECTION AND DRIFT MANAGEMENT GUIDELINES FOR OTHER HERBICIDES

- Select nozzles that produce droplets that are as large as practical to provide necessary coverage. Larger droplets are less likely to drift.
- Select the droplet size category from the nozzle manufacturer’s catalog or web site as required on the label if listed for the best weed control and nozzle type/size and drift management.
- Increase product flow rates. Higher flow rates with the proper nozzle design can reduce the chance of drift.

HERBICIDE DRIFT UPON GRAPES

- Herbicide drift can injure foliage, shoots, flowers, and fruits.
- If injury is severe enough, either from one incident or repeated exposure, it can cause reduced yield, poor fruit quality, and, occasionally, grapevine death.

TYPES OF HERBICIDES MOST HARMFUL TO GRAPES

- Herbicide injury to grapevines can last several years after the drift incident, reducing vigor, increasing susceptibility to diseases, and shortening the life of the vineyard.
- Also, drift to grapes from misapplication of pesticides could result in illegal residues on the exposed crop.

- Herbicide drift can injure foliage, shoots, flowers, and fruits.
- If injury is severe enough, either from one incident or repeated exposure, it can cause reduced yield, poor fruit quality, and, occasionally, grapevine death.

- Growth-regulator herbicides mimic auxins, which are plant hormones that regulate growth and development. This class of herbicides has a greater potential to injure grapes.
- 2,4-D, dicamba, MCPA, clopyralid, triclopyr, and a number of other compounds are classed as growth-regulator herbicides
- Field observations indicate that drift from certain growth-regulator herbicides can injure grapes half a mile or more from the application site.
GLYPHOSATE (ROUNDUP FOR EXAMPLE)
- Grapes are not as sensitive to glyphosate as they are to the growth-regulator herbicides.
- However, because glyphosate is systemic, it can translocate within grapevines and kill the growing points.
- Usually, injury in vineyards results when glyphosate applied as a directed spray to the ground under grapevines unintentionally contacts green tissues of the vines.

EFFECT OF TIME OF YEAR UPON HERBICIDE DRIFT ON GRAPES
- Spring applications of growth regulators, ALS inhibitors, and glyphosate that move off target may accumulate in the growing points of grapes, where injury symptoms first appear.
- Fall applications that result in drift may accumulate in roots.
- The type and severity of injury to grapes depends on the concentration of the herbicide, time of exposure and corresponding vine growth stage, and grape variety.

2,4-D DRIFT INJURY SYMPTOMS: (A) FAN-SHAPED LEAF WITH SMALL PUCKERED SPOTS BETWEEN VEINS AND SHARP POINTS (ENATIONS) AT LEAF MARGINS.

DICamba DRIFT INJURY SYMPTOMS: (A) LEAF CUPPING DOWNWARD OR LEAF CUPPING UPWARD

TIME OF EXPOSURE ON GRAPES
- The possibility for injury can be reduced considerably if potentially injurious herbicides are applied in early spring when grapes are still dormant (prior to bud break).
- If exposure occurs during the period of rapid shoot growth between bud break and bloom, grape injury can be severe.
- Field observations indicate that herbicide drift exposure before bloom but after bud break can cause flower abortion, curling of shoot tips, cessation of shoot growth, and regrowth of deformed leaves after exposure.

- Mid- and late-season exposure usually causes minor leaf deformation, since most shoots are fully grown and there are few developing leaves to react to the herbicide.
- Exposure of developing berries to herbicides may greatly delay or even prevent ripening.
- Injury from growth-regulator herbicides usually appears within 2 days of the drift incident.
PROTECTION FROM HERBICIDE DRIFT INJURY

- Avoid making herbicide applications during sensitive periods of grape growth and development
- Maintain good relations with neighbors. Field watch or Drift Watch programs
- Minimize drift injury from herbicides used in the vineyard.
- Avoid spraying in windy conditions or during temperature inversions.

- Use drift-reduction nozzles (for example, drift-guard or air induction types) that operate at lower pressure (15 to 30 psi for flat fans) and produce large droplets.
- Maintain a buffer - If possible, maintain a buffer from the edge of the field being treated. There are no fixed guidelines as this safe setback distance will depend on wind direction and speed, air temperature, topography, acres treated, etc.

- Leave a buffer zone of at least 350 feet between treated fields and grapevines. The buffer zone will allow larger droplets to settle before reaching grapes. The buffer zone may not be effective in settling small droplets.

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XtendiMax™ Herbicide with VaporGrip™ Technology

**Protection of Sensitive Areas:**

**Buffer Requirement**

**Downwind Buffer**

100 ft downwind buffer for applications of 4 – 8 lbs/a.

180 ft downwind buffer for applications of 9 lbs/a.

**Wind Speed and Direction**

- DRIFT PREDICTED TO TERRY BETWEEN WIND S Nothing 02 – 03.7 miles per hour.
- Do not apply at speeds greater than 10 mph.

For XtendiMax™ with VaporGrip™ Technology, wind speed and direction restrictions vary by application rate.

### Wind Speed and Application Conditions

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>Application Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3 mph</td>
<td>Do not apply XtendiMax™ with VaporGrip™ Technology.</td>
</tr>
<tr>
<td>3 – 10 mph</td>
<td>Optimum application conditions for XtendiMax™ with VaporGrip™ Technology. For all other applications requirements on the label are met.</td>
</tr>
<tr>
<td>&gt;10 – 15 mph</td>
<td>Do not apply product when wind is blowing toward non-targeted over crops.</td>
</tr>
<tr>
<td>&gt;15 mph</td>
<td>Do not apply XtendiMax™ with VaporGrip™ Technology.</td>
</tr>
</tbody>
</table>

**NOTE:** Local terrain can influence wind patterns. Every applicator must be familiar with local wind patterns and how they affect drift.

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**XtendiMax™ Herbicide with VaporGrip™ Technology**

**Preparation to Spray**

### Temperature and Humidity

- When making applications in low relative humidity or temperatures above 91 degree Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation.

### Temperature Inversions

- Do not apply this product during a temperature inversion. DRIFT PREDICTED TO TERRY BETWEEN WIND S Nothing 02 – 03.7 miles per hour.

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**Spraying**

- Minimum carrier volume of 10 GPA
  - Use higher spray volumes when treating dense vegetation
- Do not exceed 15 mph ground speed
  - Slower speeds generally result in better spray coverage and deposition on the target area
- Spray boom height: do not exceed 24" above target pest or crop canopy
  - Set boom to lowest effective height over the target pest or crop canopy based on equipment manufacturer’s directions.

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**After Spraying:**

### Tank Cleanout

- Triple-Rinse Clean-Out is Required
- Minute quantities of dicamba may cause injury to non-dicamba-tolerant soybeans and other sensitive crops
- **PROPERLY AND THOROUGHLY CLEAN SPRAY EQUIPMENT IMMEDIATELY AFTER SPRAYING Dicamba.**
  - Clean equipment immediately after using this product.
  - Prepare a cleaning solution with a commercial detergent or sprayer cleaner or ammonia according to the manufacturer’s directions for sprayer components and cleaning solutions use.
  - Spray parts can trap herbicide, and additives and surfactants can clog to surfaces.
  - All rinse water must be disposed of in compliance with local, state, and federal requirements.
**XtendiMax™ Herbicide with VaporGrip™ Technology**

**Additional Stewardship Recommendations**

Consider identifying your fields to indicate the technology planted to avoid misapplications.

- Identify sensitive crops or areas near your fields which could be impacted by spray drift.
- Consider alternative crops such as FieldWatch. Visit www.fieldwatch.com.
- Talk to your neighbors.
- Reseem site is planted near your fields.

Monsanto supports the Take Action partnership. The Take Action effort encourages the development of a proactive strategy to manage herbicide-resistant weeds that incorporates a diverse set of controls. Visit www.takeactionnow.com or contact your local extension office.

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**Engenia™ Herbicide**

**Continued Formulation Advancement**

<table>
<thead>
<tr>
<th>Dicamba</th>
<th>Form</th>
<th>Name</th>
<th>Mol. Wt.</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>H^+</td>
<td>Acid</td>
<td>1</td>
<td>Parent</td>
<td></td>
</tr>
<tr>
<td>OCH_2CH_2OCH_2OH</td>
<td>DMSO</td>
<td>45</td>
<td>Dicamba (DMSO dicamba)</td>
<td></td>
</tr>
<tr>
<td>OCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_2</td>
<td>DMF</td>
<td>106</td>
<td>Clarity™ herbicide (DMF dicamba)</td>
<td></td>
</tr>
<tr>
<td>NH_2CH_2CH_2NH_2</td>
<td>BAPMA</td>
<td>145</td>
<td>Engenia™ herbicide</td>
<td></td>
</tr>
</tbody>
</table>

BAPMA allows high loading & locks dicamba in place.

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**Engenia™ Herbicide**

**Application Innovations**

Driftable fines

**Engenia Herbicide Label Requirements**

**Dicamba-Tolerant Crops**

**TTI Nozzles Combine On-Target Application and Efficacy**

**Engenia™ Herbicide Label Requirements for DT uses only**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing</td>
<td>Bumpdown through R1 (soybean)</td>
</tr>
<tr>
<td>Nozzle</td>
<td>TTI1104</td>
</tr>
<tr>
<td>Boom Height</td>
<td>≤ 24 inches to spray target</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>0 – 15 mph (proximity to sensitive plants)</td>
</tr>
<tr>
<td>Application Volume</td>
<td>10 GPA minimum</td>
</tr>
<tr>
<td>Setback to Sensitive Areas</td>
<td>10 feet, dependent on wind speed and direction</td>
</tr>
<tr>
<td>Additives/Adjuvants</td>
<td>Tank mixtures and adjuvants approved by EPA</td>
</tr>
<tr>
<td>Spray Cleaner</td>
<td>Trioxone – use detergent-based cleaner</td>
</tr>
<tr>
<td>Weed Height</td>
<td>Less than 4'</td>
</tr>
<tr>
<td>No Aerial Applications</td>
<td></td>
</tr>
</tbody>
</table>

**TTI 11004 nozzles are available through your local BASF Representative.**
Engenia™ Herbicide
Label Requirements for Dicamba-Tolerant Crops

Wind Speed:
- Do not spray if wind is blowing in the direction of neighboring specialty crops
- 3 mph or less: Do not spray during field level temperature inversions
- Greater than 10 – 15 mph: Do not spray if wind is blowing toward neighboring sensitive crops
- Greater than 15 mph: Do not spray

Monitor wind speed and direction during application and adjust accordingly.

Engenia™ Herbicide
Sensitive Areas For Dicamba-Tolerant (DT) Crops

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
<th>Wind &amp; Buffer Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threatened and Endangered Species</td>
<td>- Native vegetation</td>
<td>- 110 buffer distance</td>
</tr>
<tr>
<td>Non-Specialty Crops</td>
<td>- Wooded areas and bodies of water</td>
<td>- 21/32 MPH wind</td>
</tr>
<tr>
<td>Specialty Crops</td>
<td>- Non-dicamba tolerant soybeans and cotton</td>
<td>- 110 buffer distance</td>
</tr>
<tr>
<td></td>
<td>- Estuaries, Sandbars, Sloughs</td>
<td>- 30/30 MPH wind</td>
</tr>
<tr>
<td>Sensitive Areas</td>
<td>- Fruiting vegetables (e.g. tomatoes)</td>
<td>- DO NOT spray if wind is blowing toward neighboring sensitive crops</td>
</tr>
<tr>
<td></td>
<td>- Cucurbits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Grapes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Trees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Residential areas</td>
<td></td>
</tr>
<tr>
<td>Non-Sensitive Areas</td>
<td>- Corn, sorghum, wheat</td>
<td>- No downwind buffer needed</td>
</tr>
<tr>
<td></td>
<td>- DT soybeans and cotton</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Upland legume fields</td>
<td></td>
</tr>
</tbody>
</table>

Engenia™ Herbicide
Example of Required Buffer

Buffer Zones: Maintain a 110 foot downwind buffer adjacent to non-specialty crop sensitive areas
- Do not allow spray to come into contact with neighboring sensitive vegetation
- Additional state restrictions may apply

Example #2:
- 80 acre DT soybean field
- West wind blowing 5 – 10 MPH with no field level inversion
- 110 buffer needed on east edge

Wind Direction

Engenia™ Herbicide
Application Success for DT Crops

The HOW
Sprayer set-up and operation

- Nozzle: TTI 11004
- Spray volume: 10 GPA or greater
- Travel speed: 15 mph or less
- Boom height: 24 inches or less
- Tank Mixtures:
  - Go to EnlistTashIn.com for the approved list of adjuvants
  - NO ammonium salts (e.g. AMS, LAN)
  - NO acidifying water conditioners

The WHEN
Decisions at application

- Buffer: 110 foot downwind buffer if required according to label directions
- Wind speed at 10 mph or less:
  - DO NOT spray if wind is blowing toward neighboring sensitive crops
- Wind speed >10 – 15 mph:
  - DO NOT spray if wind is blowing toward neighboring sensitive crops

Avoiding spray drift is manageable

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XtendiMax™ Herbicide Application Requirements:

- Nozzles that produce Ultra Coarse (UC) droplets
- Spray volume of 10 gpa or greater
- Boom height no higher than 24 inches above crop canopy
- Maximum operating pressure of 63 psi using a TTI1104 nozzle.
- Maximum ground speed of 15 mph
- Apply when wind speed is between 3 and 10 mph and avoid temperature inversions

ENGENIA™ HERBICIDE

- Use only label approved nozzle: TTI11004 from Teejet.
- Boom Height: 24 inches or less above target
- Visit www.engeniatankmix.com for a list of approved tank mix partners, adjuvants and nozzles as changes may occur prior to the 2017 spring planting season

EXAMPLES OF COMMON BROADCAST SPRAY NOZZLES FOR HERBICIDES THAT MINNESOTA CROP GROWERS AND SOME COMMERCIAL APPLICATORS MAY USE

FLAT FAN NOZZLE TECHNOLOGY

Commonly referred to as a “flat fan,” a standard hydraulic nozzle which creates the spray pattern and regulates flow at the exit orifice.

This combination of flow regulation and pattern creation at the same point can lead to an increase in droplet shear causing smaller droplets to be formed, potentially prone to drift.

Pros:
- Low cost

Cons:
- Increased drift potential
**XR Flat Fan from TeeJet**

Extended Range Flat Fan nozzle types
- replaced regular & low-pressure flat fan types
- Available in 80 and 110 degree angles.
- Wide range of pressure: 15-60 psi
- Droplet size from small to large affected by pressure. 40 psi = fine droplet size = 224 microns VMD for XR11002


**SLOW MOTION PHOTOGRAPHY OF FLAT FAN DROPLETS**

**PRE-ORIFICE NOZZLE TECHNOLOGY**

Pre-orifice spray nozzles move the point of flow regulation from the exit orifice to somewhere ‘upstream’ allowed for less shearing effect of spray droplets. Reducing droplet shear creates less droplets prone to drifting.

**TURBO FLAT-FAN FROM TEEJET**

- Turbulence chamber as in the Turbo Flood
- Tapered edge, wide angle flat pattern
- Uniform spray distribution, 50-60% overlap
- Wide pressure range, 15 – 90 psi
- Large, drift resistant droplets with 40 psi = medium droplet size = 339 VMD microns for 11002

By design, air induction spray nozzles allow air to mix with the fluid stream within the nozzle. This mixing allows air bubbles to form inside the spray droplets, increasing the potential for spray droplets to burst and adhere to targets versus droplets bouncing off. Many air induction designs also integrate a pre-orifice feature to assist in drift reduction.

AIXR (Air Induction) Flat Fan from TeeJet
- 110° wide, tapered flat spray angle with air induction technology
- Example: Droplet at 40 psi is coarse droplet size = 349 microns VMD for AIXR 11002
- Available in 0.15 to 0.6 GPM size from 15 - 90 PSI
- 2 piece all polymer construction compact size with removable pre-orifice

TURBO TEE JET® INDUCTION
- Turbo Tee Jet design with air induction pre-orifice
- Ultra Coarse Droplet Size
- Pressure rating: 15-100 psi (1-7 bar)
- Driftable fines do not increase with pressure
Droplet Sizes for TeeJet Nozzles