A Lesson in Spray Quality and Droplet Size

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Application Exclusion Zone in Outdoor Production

- EPA will explain in next talk
- Distance determined by
  - Application equipment – spray/granule
    - Air
    - Airblast
    - Fumigant, mist, fog
  - If spray
    - droplet spectrum, noted at 294 microns
    - Medium spray using VMD >294 microns

Let’s Talk about Droplets and Spray Quality
<table>
<thead>
<tr>
<th>Item</th>
<th>Diameter (μm)</th>
<th>Condition</th>
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<td>Pencil lead</td>
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<tr>
<td>Staple</td>
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<td>Light rain</td>
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<td>Toothbrush bristle</td>
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<td>Sewing thread</td>
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<td>Human hair</td>
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<td>Fine mist</td>
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<td>Point of a needle</td>
<td>1-25</td>
<td>Fog</td>
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Driftable fines under 150 μm
Spray Spectrum = Quality
Put all the Same Similar Sized Droplets in a Test Tube

Volumn of Spray

Huge drops
Big drops
Medium drops
Small drops
Tiny drops

Droplet Diameter (um)
Spray Quality and the VMD (volume median diameter)

VMD - volume median diameter - Dv0.5 (50%)

Half the total spray volume is smaller and half is larger.

This is the MEDIAN, not the average.
Spray Quality - Explained

Droplet Diameter

Volume of Spray

DV 0.1 (10%)
80 μm

DV 0.5 (50%)
305 μm

DV 0.9 (90%)
490 μm
Spray Quality - Explained

Droplet Diameter

Volume of Spray

DV 0.1
50 μm

DV 0.5
300 μm

DV 0.9
550 μm

Similar VMD
Lot’s more fines: < 150 μm
Lot’s more basketballs: > 500 μm
### Spray Quality Categories

**ASABE Standard S-572.1**

<table>
<thead>
<tr>
<th>Category (symbol)</th>
<th>Color Code</th>
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<tbody>
<tr>
<td>Extra Fine (XF)</td>
<td>Purple</td>
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<tr>
<td>Very Fine (VF)</td>
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</table>

**Spray Quality**

Based on ASABE 572.1 Standards

Referenced in nozzle charts

American Society of Agricultural and Biological Engineers
Droplet Sizing

- Measured with a laser-based instrument. Both reference and nozzles to be classified
- Verification and calibration to known standards essential
- Nozzle oriented to scan the entire spray plume
- Ensure a representative cross-sectional sample of the spray plume is obtained
ASABE 572.1 Spray Quality Standard
Plot Volume (- - -) of Droplet Sizes on a Reference Graph
### Spray Quality

#### ASABE S572.1 Droplet Size Classification

The American Society of Agricultural and Biological Engineers (ASABE) developed the ASABE S572.1 standard to measure and interpret spray quality from tips.

<table>
<thead>
<tr>
<th>Spray Quality*</th>
<th>Size of Droplets</th>
<th>VMD Range (Microns**)</th>
<th>Color Code</th>
<th>Retention on Difficult to Wet Leaves</th>
<th>Used for</th>
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*Always read the pesticide label to determine which spray quality is required.

**Estimated from sample reference graph in ASABE/ANSI/ASAE Standard S572.1

ASABE S572.1 standard uses eight droplet classification categories, six of which are common for agriculture and horticulture.
Spray Quality Color does not equate to Nozzle Color

Spray Quality Categories

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<tr>
<th>Category (symbol)</th>
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The Color Confusion Challenge: Tips and Spray Quality

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80° & 110° > fines

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XR11001 (100)
XR80015
XR110015 (100)
XR8002
XR11002 (50)
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XR110025 (50)
XR8003
XR11003 (50)
XR80035
XR11003 (50)
XR8004
XR11004 (50)
XR8005
XR11005 (50)
XR8006
XR11006 (50)
XR8008
XR11008 (50)
XR8010
XR11010 (50)
XR8015
XR11015 (50)
## A Closer Look

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## Variety and Selection

### AIXR TeeJet® (AIXR)

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Droplet Sizes Vary Among Nozzle Types
--- % of fines – less than 200 μm

†Figure 6. Comparison of percent of fine droplets (≤200 μm) for six non-venturi nozzles.

Department of Agronomy & Horticulture, University of Nebraska-Lincoln
Nozzles Today...

- TwinJet®
- Drift Guard TwinJet®
- Turbo TwinJet®
- Air Induction 3070
- Air Induction Turbo TwinJet®
- Coarse
- Quick Turbo FloodJet®
- Turbo TeeJet®
- Air Induction Induction
- Air Induction XR
- XR
- TeeJet®
- TeeJet®
XR Flat Fan Nozzle

Images from Spraying Systems

Turbo TeeJet Induction (TTI)

Older and Newer Nozzle Designs
Nozzle Comparison - 40 PSI Wind XR, AI, AIXR TeeJet®

©2009 Winfield Solutions, LLC

©2016 Winfield Solutions, LLC
Pressure Comparison Wind - 10-80 PSI Al TeeJet® AI11002

©2009 Winfield Solutions, LLC

10  20  30  40

50  60  70  80

Water
Causes of Spray Drift

1. Applicator - Decision Maker
   • To Spray or Not to Spray – to Stop Spraying
   • Equipment Set Up
   • Assesses the Weather

2. Equipment
   ▪ Droplet Size
     ▪ Tip orifice & angle
   ▪ Spray Height
   ▪ Operating Speed

3. Weather
   • Wind Direction
   • Air Flow or Wind Speed
   • Air Stability
   • Temperature and Humidity (drop size)

What Inspectors Need to Ascertain!
Spray Solution Changes Droplet Sizes

• Formulation

• Spray Adjuvants
  - Spreaders, wetting agents
  - Deposition aids

• Tank Mixes
Volume % Driftable Fines
110°/120° - 04 Nozzles @ 40 psi

10 GPA

Water alone
RoundUp PowerMAX® @ 32 oz
w/w/out Interlock @ 4 oz

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Spray Adjuvants
Some adjuvants hold droplets together, others breakup more easily!
Tank Mix Influences Droplet Size

Without drift reducing adjuvants--other adjuvants indicated by 'mix'
Other Important Droplet Issues

Relative Span (RS)

- $\text{RS} = \frac{(Dv0.9 - Dv0.1)}{\text{VMD}}$

- $Dv0.9 = 400, \ VMD = 300, \ Dv0.1 = 100$
  - Relative span = 1

- $Dv0.9 = 650, \ VMD = 300, \ Dv0.1 = 50$
  - Relative span = 2

- The narrower the RS, the greater precision
Why Use Different Spray Qualities

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<th>Category (symbol)</th>
<th>Color Code</th>
<th>Fungicides/Insecticides</th>
<th>Contact Herbicides</th>
<th>Systemic Herbicides</th>
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ASABE Standard S-572.1
# Why Use Different Spray Qualities

## Broadcast Nozzle Selection Guide

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<th>Herbicides</th>
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<td>Contact</td>
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<td><strong>Air Induction Turbo Twinjet</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td><strong>Reference page 17</strong></td>
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<td><strong>AI3070</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td><strong>Reference page 18</strong></td>
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<td><strong>Reference pages 12–13</strong></td>
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<td><strong>XR, XRC TeeJet</strong>&lt;sup&gt;4&lt;/sup&gt; at pressures below 30 PSI (2.0 bar)</td>
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<sup>1</sup> Reference page 17

<sup>2</sup> Reference page 18

<sup>3</sup> Reference pages 12–13

<sup>4</sup> Reference pages 12–13

<sup>5</sup> Reference page 8

<sup>6</sup> Reference pages 9–10
### Specialty Nozzle Selection Guide

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*Reference pages: 33, 35, 36, 37, 41, 32-39, 42-43, 45-46*
Coverage and Droplet Size

These water-sensitive papers were sprayed under controlled conditions and they demonstrate the role droplet size plays in coverage. As the droplets get finer, there are more of them, increasing coverage. However, this is really only hypothetical as many drift off target before impinging. As the droplets get coarser, there are less of them, and coverage may be compromised. To compensate for this, higher volumes are used. Credit – Dr. T. Wolf, Saskatchewan.
## Driftable Droplets*

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<td>TT – Turbo TeeJet (110°)</td>
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<td>TTJ60 – Turbo TwinJet (110°)</td>
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<td>TF – Turbo FloodJet</td>
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<tr>
<td>AIXR – Air Induction XR (110°)</td>
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<td>AITTJ60 – Air Induction Turbo TwinJet (110°)</td>
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*Data obtained from Oxford VisiSizer system spraying water at 70°F (21°C) under laboratory conditions.
## The Old Guard – XR TeeJet – Extended Range

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80 or 110
Orchard and Vineyard – ConeJets

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Aerial and Ground Droplet Calculators

2015 USDA ARS High Speed Nozzle Model

For Fixed-Wing Aircraft:
- CP-03 Nozzle Model Fixed-Wing
- CP-07 & 09 Nozzle Model Fixed-Wing
- CP 40 Degree Flat Fan (Large Orifice) Nozzle Model Fixed-Wing
- CP 40 Degree Flat Fan (Small Orifice) Nozzle Model Fixed-Wing
- CP-80 Degree Flat Fan Nozzle Model Fixed-Wing
- CP-11TT with Straight Stream Tips Model Fixed-Wing

For Rotary-Wing Aircraft:
- CP-03 Nozzle Model Rotary-Wing
- CP 40 Degree Flat Fan (Large Orifice) Nozzle Model Rotary-Wing
- CP 40 Degree Flat Fan (Small Orifice) Nozzle Model Rotary-Wing
- CP 80 Degree Flat Fan Nozzle Model Rotary-Wing
- CP-80 Degree High Volume Tips for Rotorcraft
- CP-110 Degree Flat Fan for Rotorcraft
ASABE S572.1 Droplet Size Classification

The American Society of Agricultural and Biological Engineers (ASABE) developed the ASABE S572.1 standard to measure and interpret spray quality from sprayer tips.

<table>
<thead>
<tr>
<th>Spray Quality*</th>
<th>Size of Droplets</th>
<th>VMD Range (Microns)**</th>
<th>Color Code</th>
<th>Rainfall on Difficult to Wet Leaves</th>
<th>Used For</th>
<th>Drift Potential</th>
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<tbody>
<tr>
<td>Extremely Fine</td>
<td>Small &lt;65</td>
<td>Purple</td>
<td>Excellent</td>
<td>Exceptions</td>
<td>Exceptions</td>
<td>High</td>
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<td>Very Fine</td>
<td>61-185</td>
<td>Red</td>
<td>Excellent</td>
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<td>Fine</td>
<td>196-235</td>
<td>Orange</td>
<td>Very Good</td>
<td>Good Cover</td>
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<td>Medium</td>
<td>236-340</td>
<td>Yellow</td>
<td>Good</td>
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<td>Blue</td>
<td>Moderate</td>
<td>Systemic Herbicides</td>
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<td>Liquid Fertilizer</td>
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<td>Black</td>
<td>Very Poor</td>
<td>Liquid Fertilizer</td>
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<td>Low</td>
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</table>

* Always read the pesticide label to determine which spray quality is required.
** Estimated from sample reference graphs in ASABE/ANS/SAE Standard S572.1

ASABE S572.1 standard uses eight droplet classification categories, six of which are common for agriculture and horticulture:

- **Very Fine** sprays provide enhanced retention for directed spraying on the target including:
  - Foliar-acting weed control
  - Contact-acting fungicides and insecticides
- **Medium** sprays are the most widely used spray type.
  - Used by default by most applications when spray quality is not defined by the label
  - Systemic-acting fungicides, insecticides and herbicides
- **Coarse** sprays are used with systemic, systemic, and soil-applied herbicides.

Most agrochemical applications recommend a fine, medium, or coarse spray.
Acknowledgement

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Disclaimer

• Brand names appearing in this presentation are for education and illustration purposes only.
• No endorsement is intended, not is criticism implied of similar products not mentioned.
Thank You