Reducing Spray Drift and Its Effects

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www.ag.ndsu.edu/potatoextension
Today’s Presentation

- New GM technology
- Off-site movement of herbicides
- Response of soybean to 2,4-D
- Response of soybean to Dicamba
- Effect of glyphosate on potatoes
Glyphosate-Resistant Weeds

- Glyphosate-resistant soybean became commercially available in 1996.
- Since 1996, 24 weeds have been documented to be glyphosate resistant (www.weedscience.org).
New Genetically Engineered Technology

- Resistance to:
  - 2,4-D (+ triclopyr, fluroxypyr, and fops - ACCCase inhibitors)
  - Dicamba
  - ALS
  - HPPD
Synthetic Auxin Herbicides

- 2,4-D and dicamba resistant soybean will be available in the next few years.
- Low amounts of auxin mimic herbicides can cause epinasty.
  - Epinasty: leaf crinkling, bubbling, strapping, and/or twisting and bending of petioles, branches, and stems.
Epinasty

- Epinasty can lead to reduced leaf area, changed leaf angle, and malformed growth.
- The greater the amount of epinasty is often associated with a reduction in yield potential.
Inadvertent Exposure to Herbicides

- Particle drift (including inversions)
- Volatilization
- Contamination of spraying equipment
- Misapplication
## Drift – Particle Size

### Influence of droplet size on potential distance of drift

<table>
<thead>
<tr>
<th>Droplet diameter (microns)</th>
<th>Type of droplet</th>
<th>Time required to fall 10 feet</th>
<th>Lateral distance droplets travel in falling 10 feet in a 3 mph wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fog</td>
<td>66 minutes</td>
<td>3 miles</td>
</tr>
<tr>
<td>20</td>
<td>Very fine spray</td>
<td>4.2 minutes</td>
<td>1,100 feet</td>
</tr>
<tr>
<td>100</td>
<td>Fine spray</td>
<td>10 seconds</td>
<td>44 feet</td>
</tr>
<tr>
<td>240</td>
<td>Medium spray</td>
<td>6 seconds</td>
<td>28 feet</td>
</tr>
<tr>
<td>400</td>
<td>Coarse spray</td>
<td>2 seconds</td>
<td>8.5 feet</td>
</tr>
<tr>
<td>1,000</td>
<td>Fine rain</td>
<td>1 second</td>
<td>4.7 feet</td>
</tr>
</tbody>
</table>
Coverage of Droplets

VF/F  F/M  M/C  C/VC  VC/XC

Image courtesy of Tom Wolf, Agriculture and Agri-Food Canada, Research Centre
What’s the Trade-Off?

The Trade-Off Between Spray Coverage and Drift Reduction

Coverage
Drift Reduction

Droplet size in microns
Herbicide Volatilization
Tank Contamination

- Tank Contamination
  - Soybean injury can occur from 0.01% of 8 fl oz/A dicamba
- Incomplete clean-out
  - 0.01% = 6.4 oz left after 16 fl oz/A Clarity in 500 gallon spray tank
  - 0.1% = 2 quarts left after 16 fl oz/A Clarity in 500 gallon spray tank
- Contaminated jugs or equipment
  - 0.01% = 0.05 oz or 1.5 mL Clarity in 500-gallon load
## Tank Residue Case Study

<table>
<thead>
<tr>
<th>Water source</th>
<th>Dicamba (ppb)</th>
<th>Use rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray tank</td>
<td>945</td>
<td>0.024%</td>
</tr>
<tr>
<td>Spray tank after overnight</td>
<td>822</td>
<td>0.021%</td>
</tr>
<tr>
<td>Spray boom</td>
<td>24,800</td>
<td>0.63%</td>
</tr>
</tbody>
</table>

Based on 1 pt/A Clarity applied in 15 gal/A. Spray tank cleaned out prior to test.

(Boerboom, 2004)
Response of Glyphosate-resistant Soybean to 2,4-D
Soybean Injury from 2,4-D at 14 DAT

Estimated 2,4-D dose that caused soybean injury (ED) at 14 DAT.

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>ED %</th>
<th>V2</th>
<th>V5</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>ED²₀</td>
<td>2.19</td>
<td>0.84</td>
<td>3.11</td>
<td></td>
</tr>
<tr>
<td>ED₅₀</td>
<td>9.02</td>
<td>5.97</td>
<td>18.8</td>
<td></td>
</tr>
</tbody>
</table>

- Soybean injury of 20% would need 3 to 10% of 32 fl oz/A 2,4-D solution drifting.
Yield Reduction

Estimated 2,4-D dose (ED) resulting in yield reduction.

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>ED %</th>
<th>V2 and R2</th>
<th>V5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ED_{10}</td>
<td>5.8</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.36 pt)</td>
<td>(0.26 pt)</td>
</tr>
<tr>
<td></td>
<td>ED_{20}</td>
<td>10.4</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.65 pt)</td>
<td>(0.46 pt)</td>
</tr>
</tbody>
</table>

- A 10% reduction in seed yield would need 13 to 18% solution drift of 32 fl oz/A 2,4-D.
Yield Reduction

- Reduction in the number of:
  - Main stem nodes
  - Reproductive nodes
  - Pods
  - Seeds
Can Yield Loss be Estimated from Injury Symptomology?
Soybean Yield Loss and Injury

Soybean injury from 2,4-D causing soybean yield loss (YL).

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>YL%</th>
<th>V2, V5, &amp; R2</th>
<th>% injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>YL_{10}</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YL_{20}</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Implications of 2,4-D Drift

- Injury symptoms can be difficult to detect.
- Soybean was most sensitive to 2,4-D at the V5 growth stage.
- Crop injury and yield loss take a fairly high amount of 2,4-D (13 to 18%) to cause yield loss.
- Greatest injury from 2,4-D will likely occur as a result of misapplication or tank contamination, but cultivars may vary in sensitivity.
- Soybean injury can be used as a quick and easy method to estimate yield loss, but environment and human error can result in variable estimates.
Response of Glyphosate-resistant Soybean to Dicamba Exposure
Soybean Injury from Dicamba at 28 DAT

Estimated dicamba dose that caused soybean injury (ED) at 28 DAT in 2009.

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>ED %</th>
<th>V2</th>
<th>V5</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ED_{20}</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>ED_{50}</td>
<td>0.13</td>
<td>0.04</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- Soybean injury of 20% would need 0.06 to 0.2% of 16 oz/A dicamba solution drifting.
Soybean Injury from Dicamba at 28 DAT

Estimated dicamba dose that caused soybean injury (ED) at 28 DAT in 2010.

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>ED %</th>
<th>V2</th>
<th>V5</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>fl oz/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ED₂₀</td>
<td>0.04</td>
<td>0.02</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>ED₅₀</td>
<td>0.45</td>
<td>0.13</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

- Soybean injury of 20% would need 0.1 to 0.3% of 16 oz/A dicamba solution drifting.
0% drift

0.2% drift

0.1% drift

1.6% drift
Soybean Yield Loss from Dicamba

Estimated dicamba dose that caused soybean yield loss.

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>MRC 2009 &amp; TAPC 2010</th>
<th>TPAC 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED % V2, V5, R2</td>
<td>V2</td>
<td>V5</td>
</tr>
<tr>
<td>ED10</td>
<td>0.02</td>
<td>0.31</td>
</tr>
<tr>
<td>ED20</td>
<td>-</td>
<td>0.07</td>
</tr>
</tbody>
</table>

- Soybean yield loss of 10% would need 0.03 to 1.9% of 16 oz/A dicamba solution drifting.
Can Yield Loss be Estimated from Injury Symptomology?
Soybean Yield Loss and Injury

Soybean injury from dicamba causing soybean yield loss (YL).

<table>
<thead>
<tr>
<th>Soybean growth stage</th>
<th>YL%</th>
<th>V2</th>
<th>V5 &amp; R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>YL10</td>
<td>16</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>YL20</td>
<td>42</td>
<td></td>
<td>42</td>
</tr>
</tbody>
</table>

Visual estimate of soybean injury (0 to 100%)

Seed yield loss (%)

\[ V2 \quad y = 3.01 + 0.453x - 0.001x^2, \quad R^2 = 0.92 \]

\[ V5, \quad R^2 \quad y = 0.999 - 0.037x + 0.012x^2, \quad R^2 = 0.91 \]
30% injury
Implications of Dicamba Drift

- Injury symptoms are easy to identify with dicamba. Leaf puckering is a predominate symptom.

- Soybean are sensitive to dicamba, and a small amount of drift (0.06 to 1.9% dicamba) can cause injury and yield loss.

- Soybean plants under drought stress are more sensitive to dicamba exposure.

- Soybean injury can be used as a quick and easy method to estimate yield loss, but environment and human error can result in variable estimates.
How to Mitigate Off-site Contact

• Properly clean out spray equipment
• Use appropriate nozzles and pressure
• Check wind direction
• Avoid spraying in high winds
• Check your speed—promotes boom bounce
• Avoid hot and calm days
• Use anti-drift agent
• Communicate with neighbors, staff, and local contractors
Glyphosate and Potatoes
Movement of Glyphosate

- Glyphosate will move to tubers and residues accumulate in the eyes causing sprouting problems the next year, and/or can malform potatoes.
Glyphosate Levels

- Amount: 0.007 to 0.036 ppm glyphosate
Plant-to-Plant Comparison

+ glyphosate

Normal plant
Plant-to-Plant Comparison

Normal plant

+ glyphosate
Glyphosate Residues in Seed Potato

Seed pieces with glyphosate residues had a:

- 67% reduction in total yield (from 2.25 to 0.75 lb/hill)
- 50% reduction in tuber number (10 to 5 tubers/hill)
- 38% reduction in mean tuber weight (3.9 to 2.4 oz/tuber)
Cost of Production

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Soybean</th>
<th>Wheat</th>
<th>Barley</th>
<th>Potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total operating</td>
<td>$648</td>
<td>$421</td>
<td>$300</td>
<td>$447</td>
<td>$3,000</td>
</tr>
<tr>
<td>and overhead costs</td>
<td>per acre in 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 100 acres of potatoes is worth **$300,000**.
- Damaging a potato crop is **VERY expensive**!
QUESTIONS?

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