Dicamba:
Where it happened?
How it happened?
Why it happened?

Rich Zollinger
NDSU Extension Weed Specialist
Estimates of Dicamba-injured Soybean Acreage in the U.S. as Reported by State Extension Weed Scientists (*as of October 15, 2017)

*Total: ~3.6 million

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What does this mean for dicamba?
Soybean has 0 tolerance!

- Particle drift (including inversions)
- Volatilization
- Sprayer cleanout - contamination
- Misapplication
Some things a grower can control.
Once the droplet leaves the nozzle then no control

<table>
<thead>
<tr>
<th>Summary of Application Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>HERBICIDE</td>
</tr>
<tr>
<td>AMMONIUM SULFATE</td>
</tr>
<tr>
<td>APPLICATION RATES</td>
</tr>
<tr>
<td>WIND SPEED</td>
</tr>
<tr>
<td>DOWNWIND BUFFER</td>
</tr>
<tr>
<td>SUSCEPTIBLE CROPS</td>
</tr>
<tr>
<td>GROUND SPEED</td>
</tr>
<tr>
<td>TRIPLE RANGE</td>
</tr>
</tbody>
</table>

- Sprayer should be placed at least 10 in. above target pest or crop canopy. Excessive boom height will increase the potential for drift.
Monsanto/BASF Academic Summit – Fall 2017

1. After water has evaporated:
   - What form is the dicamba deposit?
   - How much is absorbed/adsorbed?
   - Does dew solubilize dicamba deposits and cause volatility?

Physical Properties of dicamba:

2. Dissociation: Basic principle of chemistry
   - Is the BAPMA salt associated or disassociated with dicamba?
   - VaporGrip: a.i., MOA, how long associated with dicamba?
   - Under what conditions do dicamba anion and acid form?
Monsanto/BASF Academic Summit – Fall 2017

Physical Properties of dicamba:
3. pKa, Kd, Koc, vapor pressure x temperature

Environment:
4. Influence of rain/drought on fate of dicamba?

Observations:
5.
Dicamba drift on soybean:
1. Injury across entire fields (1/4 section)
2. Injury occurred 3 to 6 weeks after application
3. Injury occurred 2 to 3 times across same field
Questions:
1. What is the fate of dicamba?
2. How much dicamba is FREE?
3. In what form is free dicamba?
What does dicamba look like after water is gone?

Herbicide deposit on leaf surface
Dicamba crystallization on leaf surface

Deposit of dicamba crystals after water evaporation from droplet.

What is the fate of dicamba?
- Dissociated or acid?
- Wetting from dew?
- Wetting from light rain?
- Re-crystallized?
Questions:
1. What is the fate of dicamba?
2. How much dicamba is FREE?
3. In what form is free dicamba?
Dicamba Absorption Data

• Average absorption
  Soybean = 38-75%
  Leafy spurge = 60%
  Kochia = 35%
  Apple cuticles - 15% -30%
  ~50% absorbed
  ~50 unabsorbed!

0.25 lb of dicamba on leaf + soil surface

7.5 m lbs of dicamba FREE!
How much dicamba is adsorbed to soil?
## Dicamba Physical Properties

<table>
<thead>
<tr>
<th>Compound</th>
<th>Koc (mg/L)</th>
<th>Kd (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetamides</td>
<td>100-600</td>
<td>1.1-2.7</td>
</tr>
<tr>
<td>DNAs</td>
<td>3000-9000</td>
<td>-</td>
</tr>
<tr>
<td>EPTC</td>
<td>136-264</td>
<td>0.77-3</td>
</tr>
<tr>
<td>Sulfentrazone</td>
<td>43</td>
<td>1</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>24,000</td>
<td>324-600</td>
</tr>
<tr>
<td>2,4-D</td>
<td>20-136</td>
<td>0.17-1.27</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>~60</td>
<td>-</td>
</tr>
<tr>
<td>Fluroxypyr</td>
<td>40-71</td>
<td>0.78-1.34</td>
</tr>
<tr>
<td>Picloram</td>
<td>17-160</td>
<td>0.5</td>
</tr>
<tr>
<td>Dicamba</td>
<td>2</td>
<td>0.05-0.13</td>
</tr>
</tbody>
</table>
Questions:
1. How much dicamba is FREE?
2. What is the fate of dicamba?
3. In what form is free dicamba?
Engenia – Molecular Weight Theory

What is wrong with this picture?

- BAPMA salt reduces volatility risk

Banvel® Herbicide DMA Dicamba

Clarity® Herbicide DGA Dicamba

Engenia™ Herbicide BAPMA Dicamba
Dicamba-acid = Volatile

Dicamba-bapma or -dga or -dma

Dicamba-anion = Not volatile

Dissociation
Vapor Grip – The Great Inigma

XtendiMax with “Vapor Grip”?  
90% lower volatility than Clarity

What is Vapor Grip?  
Monsanto Academic Summit – Sept 27, 2018  
“Polymerized carboxylic acids”??

What is the mode of action of Vapor Grip?  
“Do not add acidifiers”  
“Do not add AMS”
## Dicamba Physical Properties

### Herbicide Handbook

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>pKa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraquat</td>
<td>--</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>2.6, 5.6, 10.3</td>
</tr>
<tr>
<td>2,4-D</td>
<td>2.73</td>
</tr>
<tr>
<td>Aminopyralid</td>
<td>2.56 - dissociated and (-) charge</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>2.3 - dissociated and (-) charge</td>
</tr>
<tr>
<td>Fluroxypyr</td>
<td>3</td>
</tr>
<tr>
<td>Picloram</td>
<td>2.3</td>
</tr>
<tr>
<td>Dicamba</td>
<td>1.87</td>
</tr>
</tbody>
</table>
Dicamba Physical Properties

4. XtendiMax with “Vapor Grip”?  
\[ \text{pH} < 5.5 = \text{dicamba-dga} \xrightarrow{H^+} \text{dicamba-acid} \]  
\[ \text{pH} > 5.5 = \text{dicamba-dga} \rightarrow \text{dicamba-anion} \]

Dicamba pKa = \sim 2 \text{ dissociation constant}

Low H+  
\begin{align*}  
\text{pH 6} & = 99.99 : 0.01 \text{ ratio of anionic : acid molecules} \\
\text{pH 5} & = 99.9 : 0.1 \\
\text{pH 4} & = 99:1 \\
\text{pH 3} & = 90:10 \\
\text{pH 2} & = 50:50
\end{align*}

High H+  
\begin{align*}  
\text{“} \\
\text{“} \\
\text{“} \\
\text{“}
\end{align*}
What is Vapor Grip

Dicamba-anion

BAPMA: $\text{H}_2\text{N}\overset{-}{\text{CH}}_3\overset{-}{\text{CH}}_2\overset{-}{\text{CH}}_2\overset{-}{\text{NH}}_2$

DGA: $\text{H}_2\text{N}\overset{-}{\text{O}}\overset{-}{\text{O}}\text{NH}_2$

DMA: $\text{H}_3\text{C}\overset{-}{\text{N}}\overset{-}{\text{CH}}_3$

Polyethylenimine
Mol. wt = ~2 m
Anion scavenger

Many other anions can compete with binding sites
What is Vapor Grip

Dicamba-anion

Many other cations can compete with binding sites
VaporGrip™ Technology

DMA Dicamba
(Not Approved for use in the Roundup Ready® Xtend Crop System)

Low-Volatility Dicamba with VaporGrip™ Technology

In the tank there is the potential for dicamba acid (DCH) to form in solution and create off-target movement of dicamba through volatility after spraying.

In the tank, VaporGrip™ Technology prevents the formation of dicamba acid (DCH) in solution, minimizing potential off-target movement of dicamba through volatility after spraying.

THIS PRESENTATION ON APPLICATION REQUIREMENTS IS NOT A SUBSTITUTE FOR THE PRODUCT LABELING. ALWAYS READ AND FOLLOW ALL PRODUCT LABELING.
The Ammonia Cycle
NDSU PLANT SCIENCES

Agriculture is in our roots