The Dicamba Dilemma:
Where do we go from here?

Kevin Bradley
University of Missouri
Official Dicamba-related Injury Investigations as Reported by State Departments of Agriculture (*as of October 15, 2017)

*Total: 2,708

©Dr. Kevin Bradley, University of Missouri
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
Official Dicamba-related Injury Investigations as Reported by Missouri Department of Agriculture (as of October 26, 2017)

Total: 310 complainants (335 complaints) across 52 counties
Total: 310 complainants (335 complaints) across 52 counties

Soybean Production

- >100,000 acres
- 75,000 – 99,999 acres
- 50,000 – 74,999 acres
- 25,000 – 49,999 acres
- 10,000 – 24,999 acres
- <10,000 acres
But it’s really not about the soybean acreage, it’s about adoption of the technology.

300,000 acres cotton
- ~80% Xtend (almost all sprayed w/dicamba)
- How many dicamba applications in-crop?

875,000 acres soybean
- ~65% Xtend (almost all sprayed w/dicamba)
  = 306,000 acres non-Xtend soybean
- 200,000 acres estimated to be injured with dicamba = ~2/3 of the total non-Xtend soybean

We were not close to these percentages in the rest of Missouri (i.e., the Midwest). What will happen if/when we reach these levels?
Never before has there been so much divisiveness in this industry.

“When angry, count to four; when very angry, swear.”
Weedkiller dicamba unlocks record harvests — and a web of conflict among divided farmers

By Bruce Gray, St. Louis Post-Dispatch  Oct 17, 2017  6 min to read

"This is the enemy right here," said farmer Jason Blanc as he stands next to a pigweed plant at the edge of his soybean field on Wednesday, Oct. 15, 2017, at his farm near Beach Orchard, Missouri. Blanc is busy harvesting his soybeans, rice, and cotton this month. Photo by JB/Forbes/forbes@stlpostpatch.com

A Pesticide, A Pigweed And A Farmer's Murder

STEVE INSKEEF, HOST:

There's a weed in Arkansas that can put a farmer out of business. It's called pigweed. You get one plant in your field, and that one plant can produce more than a million seeds. Many of the seeds become new plants that can choke your fields. Arkansas farmers are in a constant battle with pigweed. And last year, that battle pitted farmer against farmer. Marianne McCune from our Planet Money podcast has the story of how a war with a weed led to murder.

MARIANNE McCUNE, BYLINE: Mike Wallace was shot dead last October on a quiet county road at the edge of his field. His widow, Karen, and their son are still growing cotton and soybeans, keeping their heads up — even without Mike.

Monsanto’s Weed Killer, Dicamba, Divides Farmers

Twenty-five million acres have been planted with genetically modified seeds to encourage the spraying of the chemical. Farmers worry about damage to crops.
2) Farmers and companies

Farmers sue Monsanto, other producers over drifting herbicide

Tom Charlier, USA TODAY NETWORK – Tennessee
Published: 6:00 a.m. CT July 20, 2017· Updated: 10:35 a.m. CT July 28, 2017

After wading into waist-high soybeans that on the surface appear healthy, Mark Booni reaches deep into the plants to show their true condition.

"Here's the cupping," he said, holding some leaves that look puckered and withered.

Booni, 60, who farms 2,500 acres near Marion, Arkansas, is among a group of East Arkansas farmers suing the makers of a herbicide that they say has drifted from the fields where it was sprayed and settled onto their crops, causing major damage.

In the class-action suit, the farmers say Monsanto Co., along with BASF Corp. and DuPont, placed greed ahead of responsibility in persuading growers to spray their fields with dicamba, a product known to be highly volatile and prone to drift.

Filed in U.S. District Court in St. Louis, the suit represents a new phase of a controversy that has rolled the rural Mid-South, spawning hundreds of farmer complaints, prompting emergency state restrictions and even precipitating a fatal shooting.

Dicamba, a weed-killer sold under a number of brand names, has been around since the 1940s, but this is the first year it's been fully legal to spray on cotton and soybeans that have already have sprouted. The product is sold in conjunction with seeds that have been genetically modified to tolerate it, which allows farmers to spray the herbicide directly on their rows without damaging crops.

Missouri's largest peach farmer sues Monsanto over alleged damage from illegal herbicide use

By Bryna Gray St. Louis Post-Dispatch
Dec. 6, 2016

Marla Herman peels peaches from a conveyor belt and packs them for shipment. Guder Farm is the state's largest producer of peaches, which it distributes across a vast swath of the Midwest and the South. photo by Bryna Gray, bgray@post-dispatch.com
3) farmers and university weed scientists

*Photo courtesy of Dr. Amit Jhala, University of Nebraska.
4) non-ag public and farmers, companies, etc.
5) companies and university
weed scientists

As Dicamba Dust Settles, Scientists and Industry Spar

Monsanto Levels Criticism at Arkansas Weed Scientists
"Sad Day in Weed Science," Says One Extension Weed Scientist

By Gil Gullickson
9/11/2017

Monsanto has taken off the gloves in its effort to advance its dicamba-tolerant technology. Last week, the St. Louis-headquartered firm filed a petition with the Arkansas State Plant Board to halt what it calls an "unwarranted and misinformed ban" on dicamba in Arkansas.

Within that petition, they criticized the efforts of two well-known Arkansas weed scientists—Ford Baldwin and Jason Norrisworthy. Baldwin is a retired University of Arkansas (U of A) Extension weed scientist who now does consulting work. Norrisworthy is a U of A weed scientist.

The petition is related to an August directive that Governor Asa Hutchinson (R-AR) gave to the Arkansas agriculture secretary and plant board director to convene and cochair a dicamba task force to develop recommendations for future use of dicamba. The task force recommended that the Arkansas State Plant Board impose a flat ban on over-the-top use of all dicamba formulations after April 15 in 2018. (In 2017, only BASF’s Engenia formulation of dicamba marketed as lower in volatility than other dicamba forms was labeled for use in Arkansas.)
6) and apparently even between companies and regulatory agencies.
Factors that Contributed to the Herbicide Injury Problems Observed in 2016 and 2017

A lack of appreciation for the inherent sensitivity of soybean to extremely low concentrations of dicamba.
Lowest Observable Dose Causing Significant Visual Crop Response

Source: Dr. Bob Hartzler, Iowa State University, “Not all Drift is Created Equal”
Non-treated Control (healthy, non-injured soybean comparison)
1/20,000th of the 1x Use Rate (0.000025 lb ae/A dicamba) – 14 days after application
1/200\textsuperscript{th} of the 1x Use Rate (0.0025 lb ae/A dicamba) – 14 days after R2 application

14\% yield loss
# The Impact of Driftable Fractions of Dicamba on Non-Resistant Soybean

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate lbs ae/A (fraction of 1x*)</th>
<th>Soybean Height 2 Weeks After Trtmt</th>
<th>Soybean Yield</th>
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<tr>
<td></td>
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<td>V3 Drift Event</td>
<td>R2 Drift Event</td>
</tr>
<tr>
<td>Dicamba</td>
<td>0.000025 (1/20,000)</td>
<td>89</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>0.00025 (1/2,000)</td>
<td>85</td>
<td>93</td>
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<tr>
<td></td>
<td>0.0025 (1/200)</td>
<td>79</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>0.025 (1/20)</td>
<td>80</td>
<td>74</td>
</tr>
<tr>
<td>Control</td>
<td>----</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*1x use rate for dicamba = 0.5 lb/A.

**Numbers in red indicate significant differences from the non-treated control.

Yield Response of Soybean to Dicamba Across Different Growth Stages: Results from A Meta-Analysis

Some General Conclusions about Dicamba Injury on Soybean

• Early-season injury does not always correlate with yield loss but late-season injury generally does

• Soybean injured with typical driftable fractions of dicamba during vegetative stages will generally experience only very slight or no yield loss

• Results from a meta-analysis (12 studies) indicate:
  – flowering soybean exposed to dicamba vapor drift (~1/1000x use rate) will experience an approximate 1% yield loss
  – flowering soybean exposed to dicamba particle drift (~1/100x use rate) will experience an approximate 9% yield loss

Another Consideration: Seed Production Acres

Dicamba injury this year can affect seed next year.

- Soybean seed emergence was reduced by 50% when soybean plants were exposed to a 1/20x use rate of dicamba (0.025 lb/A) at flowering or pod filling.

- Progeny from plants treated at R1-R6 growth stages exhibited significant dicamba symptomology 14 days after planting.

2017 DICAMBA COMPLAINTS

Crops damaged as identified by complainants:
(as of 10/26/2017)
• 108,758 acres of soybeans
• 18,904 tomato plants
• 758 acres of peaches
• 132 acres of vineyards
• 130 acres of rice
• 122 acres of watermelons
• 35 acres of alfalfa
• 24 acres certified organic vegetables
• 15 acres of pecan trees
• 12 acres of apple trees
• 11 commercial gardens
• 10 acres of cantaloupes
• 2 acres of pumpkins
• 900 mums
• 40 residential properties (gardens/trees/shrubs)
Personal Observations:

People have started to notice what’s happening to the trees.
Pines in Mississippi
Sycamores in Tennessee
Influence of Driftable Fractions of Dicamba on Peach Trees

1/200X (0.0025 lb dicamba)  1/20X (0.025 lb dicamba)  1/2X (0.25 lb dicamba)

*pictures taken 28 days after treatment
Symptoms of Dicamba on Pin Oak, 112 Days After Treatment

Non-Treated

0.025 lb dicamba (1/20X rate)
Symptomology of Driftable Fractions of Dicamba on Maple Leaves

- Non-Treated
- 0.0025 lb dicamba 1/200th rate
- 0.025 lb dicamba 1/20th rate
- 0.25 lb dicamba ½ rate
Reasons?

#1 Physical Drift

- wind
- height
- dust
- nozzles
- boom
Physical drift usually can be distinguished as clear patterns of injury that are more severe closest to the spray source.
Comparing Historical and 2017 Wind Speeds: Southeast Missouri

April

May

June

July
Comparison of a Turbo TeeJet Induction Nozzle with an Extended Range Flat Fan Spray Tip

XR11003VS  40PSI

TTI11004  40PSI

©Dr. Greg Kruger, University of Nebraska
Reasons?

#2 Tank Contamination

- inadequate tank cleaning
- contaminated pumps, bulk tanks, etc.
Spray Tank Contamination

Based on our results, spraying a dicamba-resistant soybean field with a standard rate of dicamba and then...

leaving 8 fl ozs of solution in a 1,200 gallon spray tank would result in **significant injury** to a subsequent non-DR soybean field.
Equipment Cleanout Following Dicamba Application

**Non-treated control**

**Single rinse water**

**Double Rinse**
- 1st rinse water;
- 2nd rinse ammonia

**Triple Rinse**
- 1st rinse water;
- 2nd rinse ammonia;
- 3rd rinse water

**Yield:**
- 48 Bu/A
- 37 Bu/A
- 44 Bu/A
- 48 Bu/A
Reasons?

#3 Temperature Inversions

Night-time spraying

volatility
How Common are Surface Temperature Inversions in Mid-Missouri?

### Mid Missouri

<table>
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<tr>
<th>Month</th>
<th>2015</th>
<th>2016</th>
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<tbody>
<tr>
<td>March</td>
<td>25</td>
<td>18</td>
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<td>21</td>
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<td>May</td>
<td>14</td>
<td>16</td>
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<td>June</td>
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<td>14</td>
</tr>
<tr>
<td>July</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

*Bish and Bradley, unpublished*
Typical Start and Stop Times for Inversions in mid-Missouri (3 yr average)

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inversion conditions</td>
<td>6:15 PM</td>
<td>6:20 PM</td>
<td>6:50 PM</td>
<td>7:32 PM</td>
</tr>
<tr>
<td>begin forming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inversion conditions</td>
<td>6:10 AM</td>
<td>6:00 AM</td>
<td>5:35 AM</td>
<td>5:45 AM</td>
</tr>
<tr>
<td>dissipate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Start and stop times recorded from 2015 to 2017 at Bradford Research Farm; modes shown in table
Using Smoke Grenades to Validate our Inversion Modeling (June 8, 2017)

- Released at 4:00, No Inversion Present
  - at release
  - during dispersion
  - 50 seconds after release

- Released at 7:30, Inversion Present
  - at release
  - during dispersion
  - 50 seconds after release
Monitoring Surface Temperature Inversions in Missouri

Expanding the Network in 2017

A Project Funded by:

[Missouri Soybeans Logo]
Real Time Monitoring for Inversion-like Conditions

http://agebb.missouri.edu/weather/realTime/maps/index.php#temp_inversion

Funding for this project made possible by the Missouri Soybean Merchandising Council
Reasons?

#4 Volatility
In trials, Engenia exhibited 70% lower volatility relative to DGA-based Dicamba.

1Volatility ratings using five different measurement techniques: Field testing, Humidome, TGA, C14, Incubator
Relative Volatility of XtendiMax Containing VaporGrip™
Some University Results with Dicamba Volatility Testing in 2017
Dicamba Air Concentrations Following Engenia and Xtendimax Applications

Applications included glyphosate $K^+$, made in the evening, no inversion present.

One experiment; bars represent standard error of the mean.
Soybean “Indicator Plant” Response following Application of Engenia and Xtendimax

*Photos taken 21 days after application*
Time of Application

Daytime and nighttime application experiments conducted twice, with 3 air samplers per experiment.
Means followed by the same letter are not different, LSD = 0.05.
Field Volatility of Dicamba, Knoxville, TN
June 2017

Source: Dr. Tom Mueller, University of Tennessee
Low Tunnel Experiments

- Treated flats were placed between two rows of soybeans in the center of the dome, and plastic sheeting was placed over the dome frame.
- Treated flats and plastic sheeting were removed 48 hours after application.
**PRELIMINARY 2017 DATA**

Dicamba Volatility by Herbicide

Field Low Tunnel Experiment

**Methods:** Sprayed 3 flats with bare soil for each treatment and placed in the center of 2 soybean rows. Injury rating is for soybean plants immediately adjacent to the flats.

![Bar Graph showing Soybean Injury (%)](chart.png)

- **X-axis:** 21 DAT
- **Y-axis:** Soybean Injury (%)
Low Tunnel Experiment, Lanoke Arkansas (Dr. Bob Scott)

Source: Dr. Bob Scott, University of Arkansas
19 days after application

Xtendimax + RdP P2
Engenia + RdP P2
Roundup Xtend
Banvel + RdP P2

Source: Dr. Jason Norsworthy, University of Arkansas
Source: Dr. Jason Norsworthy, University of Arkansas
Large-Scale Study

Xtendimax – 14 Days After Treatment

Applied at 11:00am
Ave wind speed 5.25 mph

0 to 9 hours – Wind from the SW
9 to 11.5 hours – Wind from the E

Dr. Greg Kruger, Univ. of Nebraska

Graph shows the soybean injury (%) over distance from application (ft) for different wind directions and times.
Some Practical Considerations

The acreage planted with dicamba-resistant soybean in the U.S. is expected to at least **double** next year.

**Acres Custom Applied by Agricultural Retailers, 2015**

- No Custom Application: 7
- <10,000 acres: 5
- 10,001 - 25,000 acres: 11
- 25,001 - 50,000 acres: 17
- 50,001 - 75,000 acres: 21
- 75,001 - 100,000 acres: 14
- >100,000 acres: 25

Will it be possible to get it all sprayed **and** follow federal and state requirements **and** make timely applications?

Graph adapted from Erickson and Widmar, 2015. Precision agricultural services dealership survey results.
Some Practical Considerations

The acreage planted with dicamba-resistant soybean in the U.S. is expected to at least **double** next year.

Will it be possible to get it all sprayed **and** follow federal and state requirements **and** make timely applications?

*Slide content provided by: Bill Johnson and Joe Ikley, Purdue University and Bob Hartzler and Meaghan Anderson. Iowa State.*
Some Practical Considerations

This has already and is currently being marketed and sold as the “next solution”.

BASF Touts 2017 Success for Dicamba Herbicide and 2018 Plans

Scott Kay, Vice President, BASF U.S. Crop Protection, said those farmers’ stewardship of the technology is a key to their success.

“I spent time talking to growers in Illinois, Iowa, and Indiana, and I talked to them directly about their stewardship,” he said. “What did they do? What was their best practice? What made for a successful Glycine herbicide application? Following an application checklist, I think, came out in nearly every conversation. They clearly had a plan and they had been trained on that plan. Using approved nozzles was also critical, as they had to change what they did before and adopted the new technology and new nozzles specific for this application. We gave away over 700,000 of those nozzles this past summer.”

The added success also depended on understanding what was in nearby fields and maintaining a good line of communication with BASF representatives.

In the new round of training BASF Technical Marketing Manager Chad Amsus says they will share all they have learned from the mistakes farmers have made this year.

“Improper nozzles, improper boom height, wind speed and direction, in many cases crop spray system hygiene, understanding how sensitive soybeans can be to small doses of dicamba and potential contamination points within the mixing and loading process.” Amsus added, “We also identified in some geographic nighttime applications and applications during a temperature inversion.”
Some Practical Considerations

This technology provides us with a valuable pre-plant tool for marestail, ragweed, etc. It may be that we may need to sacrifice post-emergence use of dicamba on waterhemp and Palmer amaranth in order to preserve it.
MO Requirements

1. **Restricted Use Pesticide**: For sale and use ONLY by certified applicators.

2. **Training Requirement**: Must complete mandatory training provided by us (online or in person)
MU Synthetic Auxin Herbicide Training

$30/person regardless of which option you choose

**Online:**
4 modules, expected to be ready January 2\textsuperscript{nd}

**In-person Events (must pre-register):**

**January 10, 2018:** Springfield, Missouri
Ramada Plaza Hotel and Oasis Convention Center
2546 North Glenstone, Springfield, MO 65803

**January 22, 2018:** Blue Springs, Missouri
Adams Pointe Conference Center at the Marriott Courtyard
1500 NE Coronado Dr, Blue Springs, MO 64014

**February 9, 2018:** Columbia, Missouri
Stoney Creek Hotel & Conference Center
2601 S Providence Rd, Columbia, MO 65203

**February 12, 2018:** Hannibal, Missouri
Quality Inn & Suites
120 Lindsey Drive, Hwy 36, Hannibal, MO 63401

**February 13, 2018:** Sikeston, Missouri
City of Miner Convention Center
2610 E Malone Ave, Sikeston, MO 63801
MO Requirements

1. **Restricted Use Pesticide:** For sale and use ONLY by certified applicators.

2. **Training Requirement:** Must complete mandatory training provided by us (online or in person)

3. **Notice of Application Form:** Online daily prior to each application

4. **Application Timing:** 7:30-5:30

5. **Cutoff Dates** – June 1 in 10 southeast counties; July 15 everywhere else
Flowering Progress for Missouri Soybean – 2017

Source: NASS