# Injury Criteria Associated with Soybean Exposure to Dicamba and Potential for Yield Loss Prediction

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# Dicamba in 2017

- <u>Arkansas</u>: 924 dicamba complaints filed (Arkansas Agricultural Department August 18, 2017)
- <u>Missouri</u>: 287 dicamba complaints filed (Missouri Department of Agriculture August 17, 2017)
- <u>Tennessee</u>: 118 dicamba complaints under investigation (Bradley August 10, 2017)
- <u>Mississippi</u>: 72 dicamba complaints made to the Department of Agriculture and Commerce (Bradley August 10, 2017)
- Complaints also reported in Iowa, Ohio, Illinois, Indiana, Kansas, Kentucky, Minnesota, Nebraska, North Carolina, North Dakota, and South Dakota

# Objectives

- To determine the negative effects of dicamba on soybean growth and yield
- To to develop a model to predict soybean yield loss following dicamba exposure
- To validate the model and develop a software package/APP for use in yield loss prediction



# **Materials and Methods**

#### Location:

- Central Research Station in 2013, 2014, and 2015
- Soil type: clay loam

#### Varieties:

 Indeterminate MG 4.8 to 5.1 soybean planted in early May to early June

#### Herbicide Treatments:

- Dicamba (Clarity diglycolamine salt) at 1/64, 1/32, 1/16, 1/8, 1/4, 1/2, 1, 2, 4, and 8 oz/A; 1/1000 to 1/2 of the use rate of 16 oz/A
- Nonionic surfactant at 0.25% v/v added to all treatments
- CO<sub>2</sub> backpack sprayer used with 15 GPA spray volume @ 30 psi
- Non-treated included for comparison



# **Materials and Methods**

#### **Application Timing:**

- V3/V4 (third/fourth node with 2/3 fully expanded trifoliates)
- R1/R2 (open flower at any node on main stem/open flower at one of the two uppermost nodes on main stem)

#### Plot Size:

4 rows (30 inch spacing) x 30 feet;2 inner rows treated

#### **Experimental Design:**

 RCB with factorial arrangement of treatments (dicamba rate x application timing) and four replications



# **Materials and Methods**

#### Data Collected:

- Fourteen injury criteria identified
- Rated 7 and 15 d after dicamba application (DAA) on a severity scale of 0 to 5 with 0= no injury; 1= slight; 2= slight to moderate (producer concern); 3= moderate; 4= moderate to severe; and 5= severe
- Overall visual assessment of soybean injury and visual height reduction made on 0 to 100% scale and soybean canopy height determined 7 and 15 DAA
- Mature plant height and yield determined

#### Data Analysis:

- ANOVA and Tukey-Kramer (P<0.05)</li>
- Regression analysis
- Multiple linear regression to develop yield prediction model (to be discussed later)



## Fourteen Dicamba Injury Criteria

- Upper canopy:
  - leaf cupping
  - leaf surface crinkling
  - pale leaf margins
  - leaf rollover/inversion
- Lower leaf soil contact
- <u>Leaf petiole</u>:
  - droop
  - base swelling



- cupping
- chlorosis
- necrosis
- epinasty
- Stem epinasty
- Lower stem:
  - base swelling
  - lesions/cracking









# **Leaf Injury Criteria**









Leaf Petiole Base Swelling

#### **Injury Severity Based on:**

0-5 scale: 0= no injury; 1= slight; 2= slight to moderate (producer concern); 3= moderate; 4= moderate to severe; 5= severe

## **Terminal Injury Criteria**







Injury Severity Based on: 0-5 scale: 0= no injury; 1= slight; 2= slight to moderate (producer concern); 3= moderate; 4= moderate to severe; 5= severe

## **Stem Injury Criteria**







Stem Cracking

#### **Injury Severity Based on:**

0-5 scale: 0= no injury; 1= slight; 2= slight to moderate (producer concern); 3= moderate; 4= moderate to severe; 5= severe

## Soybean Yield as Influenced by Soybean Growth Stage



# **Predicted Soybean Yield Loss**

- Volatility
  - 0.1% of the use rate (Egan and Mortensen 2012)
  - 1/64 oz/A dicamba
    - V3/V4 (1%) and R1/R2 (2%)

### Spray particle drift

- -1.0 to 8% of the use rate (Maybank et al. 1978)
- 1/8 oz/A to 1 oz/A dicamba
  - V3/V4 (9 to 54%) and R1/R2 (17 to 76%)
- As high as 16% of the use rate (Wolf et al. 1992)
- 2 oz/A dicamba
  - V3/V4 (79%) and R1/R2 (94%)



## Soybean Mature Height as Influenced by Soybean Growth Stage



## Value of Yield Prediction Models?

- Aid in critical decisions regarding:
  - Replanting of the crop
  - Additional crop inputs
  - Crop insurance claims
  - Liability issues
- "Gut feeling" currently only method of predicting soybean yield loss





### **Development of Model to Predict Yield**

- Multiple linear regression analysis with a forward/stepwise selection procedure was used to analyze the 2013-2015 data
  - Separate analysis was performed for V3/V4 application at 7 and 15 DAA and for R1/R2 application 7 and 15 DAA
  - 14 injury criteria plus overall visual injury, visual height reduction, and canopy height were analyzed to determine their relationship to soybean yield
- For each application timing and DAA, only six of the seventeen variables were selected for use in the models to predict soybean yield
- By knowing the yield for the non-treated, yield loss can be calculated

# Variables Included in Models

| V3/V4 exposure         |                        | R1/R2 exposure         |                        |
|------------------------|------------------------|------------------------|------------------------|
| 7 DAA                  | 15 DAA                 | 7 DAA                  | 15 DAA                 |
| visual height          | lower stem base        | visual height          | lower stem base        |
| reduction (%)          | lesions/cracking (0-5) | reduction (%)          | lesions/cracking (0-5) |
| lower leaf soil        | visual height          | lower stem base        | terminal leaf          |
| contact (0-5)          | reduction (%)          | lesions/cracking (0-5) | chlorosis (0-5)        |
| lower stem base        | terminal leaf          | leaf petiole droop     | leaf petiole base      |
| lesions/cracking (0-5) | epinasty (0-5)         | (0-5)                  | swelling (0-5)         |
| canopy height (cm)     | leaf petiole droop     | upper canopy leaf      | stem epinasty          |
|                        | (0-5)                  | rollover/inversion     | (0-5)                  |
|                        |                        | (0-5)                  |                        |
| overall visual injury  | leaf petiole base      | leaf petiole base      | terminal leaf necrosis |
| (%)                    | swelling (0-5)         | swelling (0-5)         | (0-5)                  |
| upper canopy leaf      | stem epinasty          | stem epinasty          | terminal leaf cupping  |
| surface crinkling      | (0-5)                  | (0-5)                  | (0-5)                  |
| (0-5)                  |                        |                        |                        |

# **Prediction Equations**

### • <u>V3/V4</u>



- <u>7 DAA</u>:  $\hat{Y}$  = Intercept value 0.30 (visual height reduction) 3.77 (lower leaf soil contact) 4.25 (lower stem base lesions/cracking) 0.76 (canopy height) 0.27 (overall visual injury) + 1.71 (upper canopy leaf surface crinkling)
- <u>15 DAA</u>: Ŷ = Intercept value 4.08 (lower stem base lesions/cracking) 0.46 (visual height reduction) + 5.38 (terminal leaf epinasty) 5.92 (leaf petiole droop) + 4.21 (leaf petiole base swelling) 3.77 (stem epinasty)

### • <u>R1/R2</u>

- <u>7 DAA</u>: Ŷ = Intercept value 0.77 (visual height reduction) 6.93 (lower stem base lesions/cracking) 1.60 (leaf petiole droop) + 1.93 (upper canopy leaf rollover/inversion) 2.95 (leaf petiole base swelling) + 1.78 (stem epinasty)
- <u>**15 DAA:**</u>  $\hat{Y}$  = Intercept value 10.37 (lower stem base lesions/cracking) 3.92 (terminal leaf chlorosis) 4.68 (leaf petiole base swelling) + 3.90 (stem epinasty) 2.46 (terminal leaf necrosis) 1.70 (terminal leaf cupping)

# Validation of Models

- Experiments conducted in Baton Rouge and St. Joseph, LA in 2016 using 'Asgrow 4835', an indeterminate MG 4.8 cultivar
- Dicamba formulation, rates, and application timings same as used to develop the models
  - Clarity (diglycolamine salt) at 1/64 to 8 oz/A (1/1000x to 1/2x) plus 0.25% v/v NIS
  - V3/V4 (third/fourth node with 2/3 fully expanded trifoliates) and R1/R2 (open flower at any node on main stem/open flower at one of the two uppermost nodes on main stem)





# Validation of Models (Continued)

- Data were collected for the six variables specified by the model for each application timing and DAA
- Plots harvested to determine yield; nontreated yields of 67 Bu/A at Baton Rouge and 82 Bu/A at St. Joseph
  - Percent yield reduction vs. nontreated was calculated for each dicamba rate
- Using the models (equations), yield for each dicamba rate was <u>predicted</u> and percent yield reduction vs. nontreated was calculated
- To test the models, <u>predicted</u> percent yield reduction for each dicamba rate was compared to <u>actual</u> percent yield reduction





### Validation Study Results Averaged Across Locations 15 DAA for V3/V4 Application

|                 |                        |                   | Difference between   |
|-----------------|------------------------|-------------------|----------------------|
| Dicamba rate    | Average actual yield   | Average predicted | predicted and actual |
|                 | (Bu/A) / percent yield | percent yield     | yield reduction      |
| (oz/A)          | reduction              | reduction         | (percentage points)  |
| 0               | 74.3                   |                   |                      |
| 1/64 (1/1000 x) | 66.1/11%               | 12%               | +1 <mark>-</mark>    |
| 1/32 (1/512 x)  | 63.1/15%               | 17%               | +2                   |
| 1/16 (1/256 x)  | 59.7/20%               | 20%               | 0 Avg =              |
| 1/8 (1/128 x)   | 56.5/24%               | 22%               | (-2) +1.8            |
| 1/4 (1/64 x)    | 52.8/29%               | 37%               | +8                   |
| 1/2 (1/32 x)    | 50.4/32%               | 52%               | +20                  |
| 1 (1/16 x)      | 41.7/44%               | 72%               | Avg = +28            |
| 2 (1/8 x)       | 18.9/75%               | 89%               | +21 +14              |
| 4 (1/4 x)       | 7.6/90%                | 99%               | +9                   |
| 8 (1/2 x)       | 0/100%                 | 99%               | -1                   |

### Validation Study Results Averaged Across Locations 15 DAA for R1/R2 Application

|                 |                        |                   | Difference between   |
|-----------------|------------------------|-------------------|----------------------|
| Dicamba rate    | Average actual yield   | Average predicted | predicted and actual |
|                 | (Bu/A) / percent yield | percent yield     | yield reduction      |
| (oz/A)          | reduction              | reduction         | (percentage points)  |
| 0               | 73.8                   |                   |                      |
| 1/64 (1/1000 x) | 64.8/12%               | 16%               | +4 -                 |
| 1/32 (1/512 x)  | 61.8/16%               | 18%               | +2                   |
| 1/16 (1/256 x)  | 58.7/21%               | 27%               | +6                   |
| 1/8 (1/128 x)   | 54.3/26%               | 30%               | +4                   |
| 1/4 (1/64 x)    | 41.9/43%               | 36%               |                      |
| 1/2 (1/32 x)    | 32.6/56%               | 60%               | +4 Avg - +1.2        |
| 1 (1/16 x)      | 16.3/78%               | 77%               | -1                   |
| 2 (1/8 x)       | 8.9/88%                | 88%               | 0                    |
| 4 (1/4 x)       | 4.8/94%                | 97%               | +3                   |
| 8 (1/2 x)       | 0/100%                 | 97%               | -3                   |

# **Results - Validation Study**



- Ability of the models to predict soybean yield loss was greater 15 days after dicamba application compared with 7 days (data not shown)
- V3/V4 exposure 15 DAA of dicamba at 1/64 to 1/4 oz/A
  - Average actual yield loss was of 11 to 29%
  - The model underestimated average actual yield reduction by 2 percentage points or overestimated by as much as 8 percentage points
  - Average difference in percentage points between predicted and actual yield was 1.8
- <u>R1/R2 exposure 15 DAA of dicamba at 1/64 to 8 oz/A</u>
  - Average actual yield loss was of 12 to 100%
  - The model underestimated average actual yield reduction by as much as 7 percentage points or overestimated by as much as 6 percentage points
  - Average difference in percentage points between predicted and actual yield was 1.2



# Summary/Conclusions



- Injury criteria and severity of injury varied (rate and growth stage dependent)
- Greater yield reduction at the reproductive growth stage
- Soybean yield loss at a rate of 1/1000<sup>th</sup> of the use rate (exposure associated with volatility)
  - 1% for V3/V4 application and 2% for R1/R2 application
- Soybean yield loss at a rate of 1 to 8% of the use rate (exposure associated with spray particle drift)
  - 9 to 54% for V3/V4 application and 17 to 76% for R1/R2 application
- Soybeans have the ability to recover even when severe injury symptoms are observed
- A U.S. patent regarding the yield loss prediction model was filed in November of 2017
- Next step Develop software package/App (In progress)

# **Questions?**

