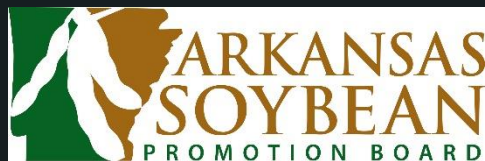


Crop Wars: The Pigweed Strikes Back



National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE



2021 Indiana CCA Conference

Indianapolis, IN

Dr. Thomas R. Butts

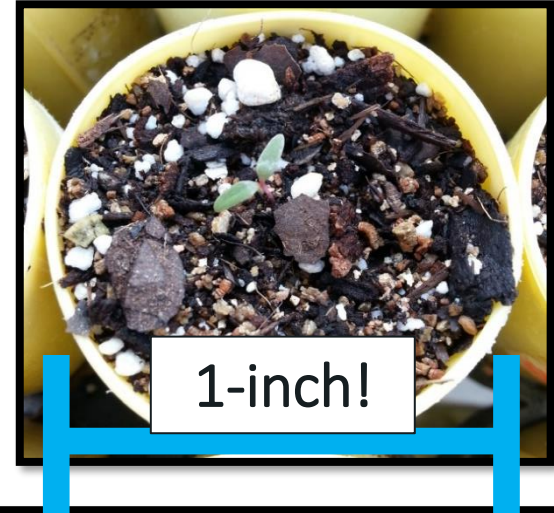
14 Dec. 2021

Pigweeds (*Amaranthus spp.*)

- Summer annuals
- Small seeded (black and shiny)
- Oval-diamond shaped, alternate leaves
- Mainly erect-bushy plants
- Dense inflorescences



What's the Big Deal with Pigweeds?



Prolific Growth
Characteristics!

Horak and Loughlin (2000). Weed Sci 48:347–355; Sellers et al. (2003). Weed Sci 51:329–333.



Tricky Germination Timings

- Palmer amaranth and waterhemp emerge later than a lot of other weeds...
- They like temperatures to be at least 75°F during the day
 - In the Midwest, this is around the beginning to mid June
 - In the South, this is beginning to mid May
 - Control can be challenging as it is likely after the crop is planted



Will germinate
throughout entire
growing season as long
as temperatures
persist

When did these
germinate?



Pigweed Herbicide Resistance (U.S.)



- Palmer amaranth and waterhemp have been confirmed resistant to:
 - ALS Inhibitors – Group 2 (Raptor, Pursuit, Scepter)
 - Photosystem II Inhibitors – Group 5,6,7 (Atrazine, metribuzin)
 - Microtubule Inhibitors – Group 3 (Prowl, Treflan)
 - EPSPS Inhibitors – Group 9 (glyphosate)
 - HPPD Inhibitors – Group 27 (Laudis, Callisto)
 - PPO Inhibitors – Group 14 (Flexstar, Ultra Blazer, Valor)
 - VLCFA Inhibitors – Group 15 (Dual Magnum, Zidua, Warrant, Outlook)
 - Synthetic Auxins – Group 4 (2,4-D, dicamba)
 - Glutamine Synthetase Inhibitor – Group 10 (Liberty)
- **Multiple resistance also identified:**
 - Arkansas and Kansas have identified 5-way resistant Palmer
 - Iowa, Nebraska, and Illinois have 4-, 4-, and 5-way resistant waterhemp, respectively



Pigweed Herbicide Resistance (Neighbors)

■ Indiana (waterhemp):

- ALS Inhibitors (Raptor, Pursuit, Scepter)
- EPSPS Inhibitors (glyphosate)
- PPO Inhibitors (Flexstar, Ultra Blazer, Valor)

■ Illinois (waterhemp):

- ALS Inhibitors (Raptor, Pursuit, Scepter)
- EPSPS Inhibitors (glyphosate)
- PPO Inhibitors (Flexstar, Ultra Blazer, Valor)
- PSII Inhibitors (atrazine)
- HPPD Inhibitors (Laudis, Callisto)
- Synthetic Auxin (2,4-D, dicamba)
- VLCFA Inhibitors (Dual Magnum, Outlook, Warrant, Zidua)

■ Ohio (waterhemp):

- ALS Inhibitors (Raptor, Pursuit, Scepter)
- EPSPS Inhibitors (glyphosate)

■ Michigan (waterhemp):

- ALS Inhibitors (Raptor, Pursuit, Scepter)

■ Kentucky (waterhemp):

- EPSPS Inhibitors (glyphosate)

■ Indiana, Kentucky, Michigan, & Ohio (Palmer amaranth):

- EPSPS Inhibitors (glyphosate)

■ Illinois (Palmer amaranth):

- EPSPS Inhibitors (glyphosate)
- ALS Inhibitors (Raptor, Pursuit, Scepter)
- PPO Inhibitors (Flexstar, Ultra Blazer, Valor)



Palmer amaranth Herbicide Resistance in Arkansas

Palmer amaranth has been confirmed resistant to 7 sites-of-action in AR:

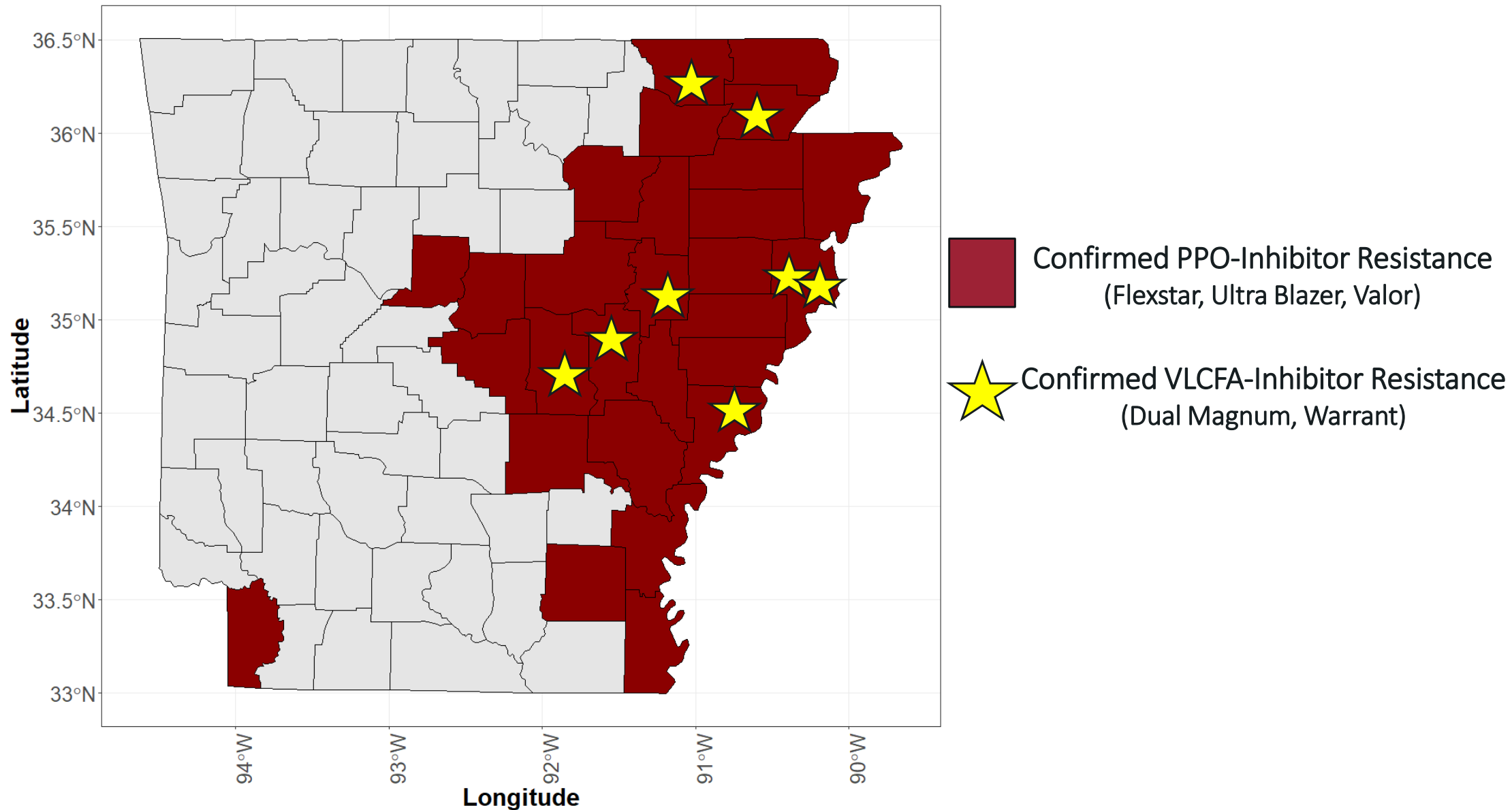
- EPSPS Inhibitors – Group 9 (glyphosate)
- Dinitroanilines – Group 3 (Prowl, Treflan)
- ALS-Inhibitors – Group 2 (Raptor, Pursuit)
- HPPD-Inhibitors – Group 27 (Laudis, Callisto)
- PPO-Inhibitors – Group 14 (Flexstar, Ultra Blazer, Valor)
- VLCFA-Inhibitors – Group 15 (Dual Magnum, Warrant)
- Glutamine Synthetase Inhibitor – Group 10 (Liberty)
- Synthetic Auxins – Group 4 (2,4-D, Dicamba) *Next on the list?*

Considered to be isolated areas
at this time, not widespread.

These three resistances are typically assumed to be in 100% of
the Palmer amaranth populations in the state.

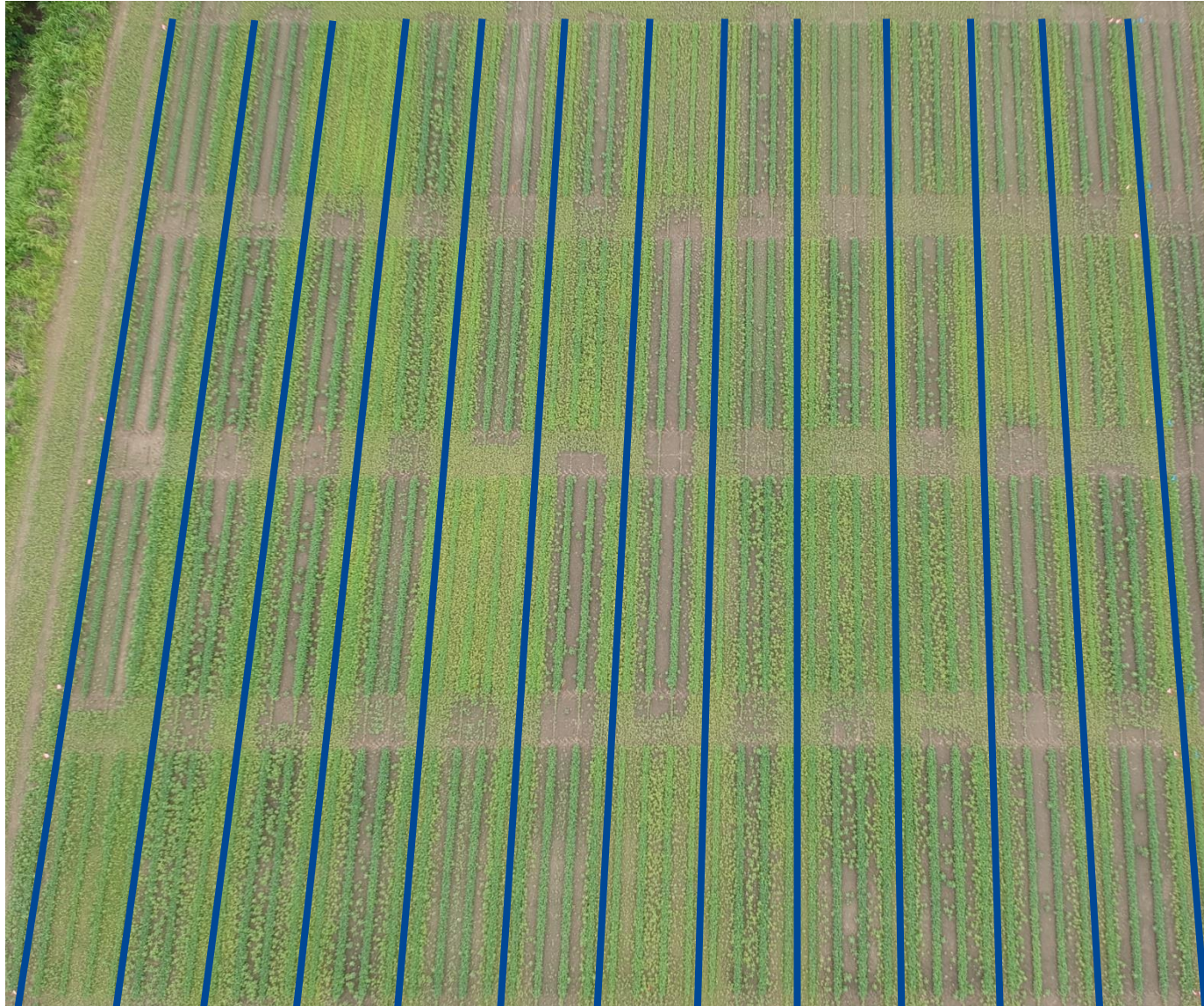


Palmer amaranth Herbicide Resistance in Arkansas

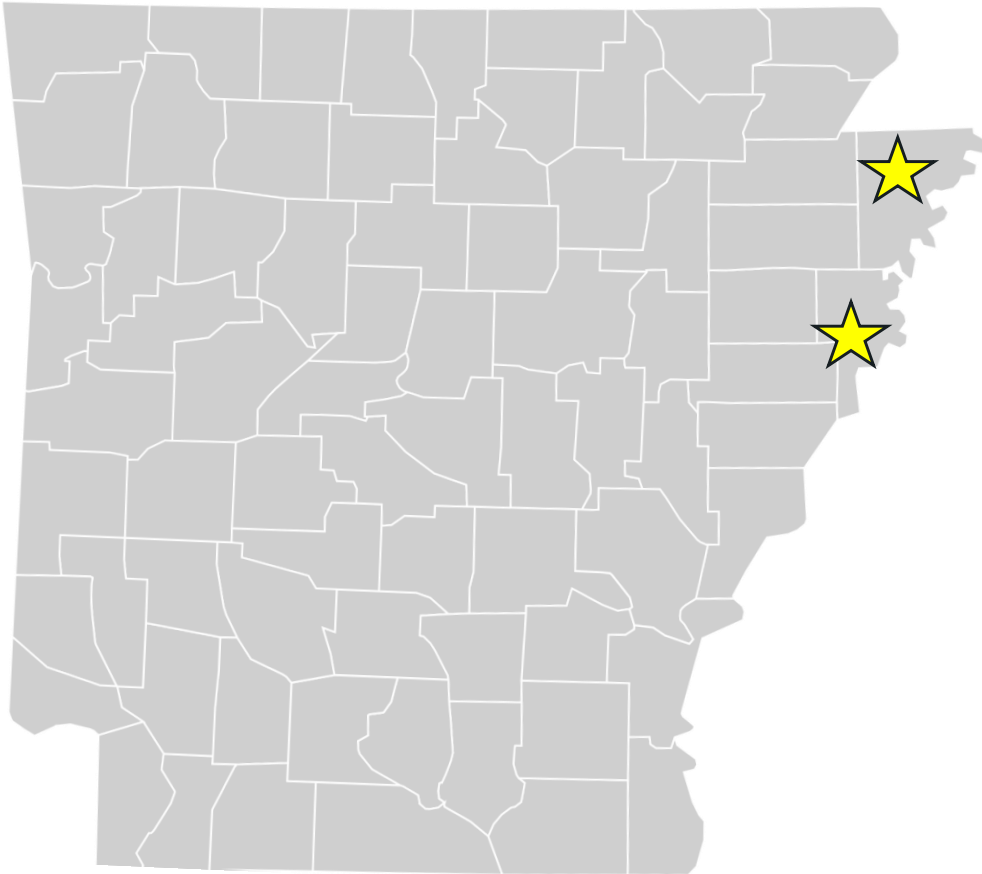


Aerial View – 36 Days After Application

Marion, AR



Glufosinate Resistance



Confirmed Glufosinate Resistance
(Liberty)



Arkansas Palmer amaranth response to glufosinate



16 fl oz/A

32 fl oz/A

128 fl oz/A

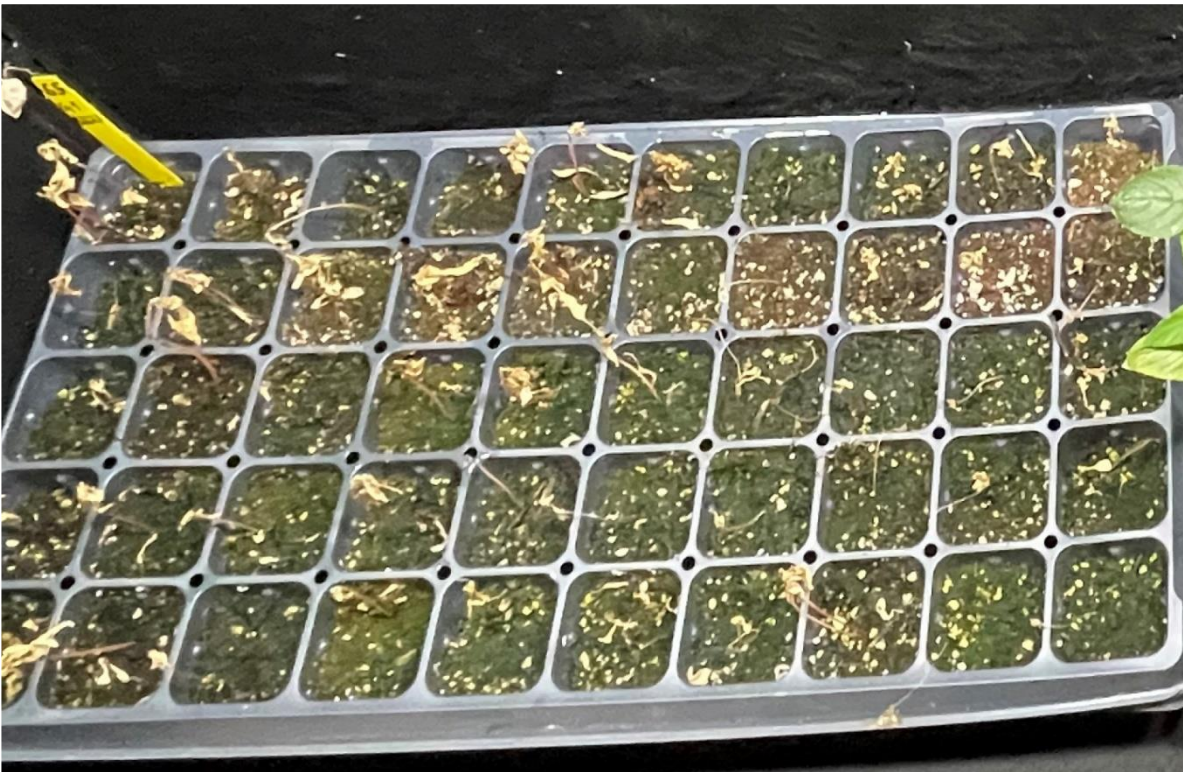
256 fl oz/A

Liberty rate

Accession 20-59 (Mississippi Co.)



Glufosinate Resistance



Susceptible



Accession 20-59
(Mississippi County)

32 fl oz/A Liberty

Herbicide program for LibertyLink cotton in 2019



Accession 19-62

Crawfordsville, Arkansas



So pigweeds are a huge problem...

What can we do?



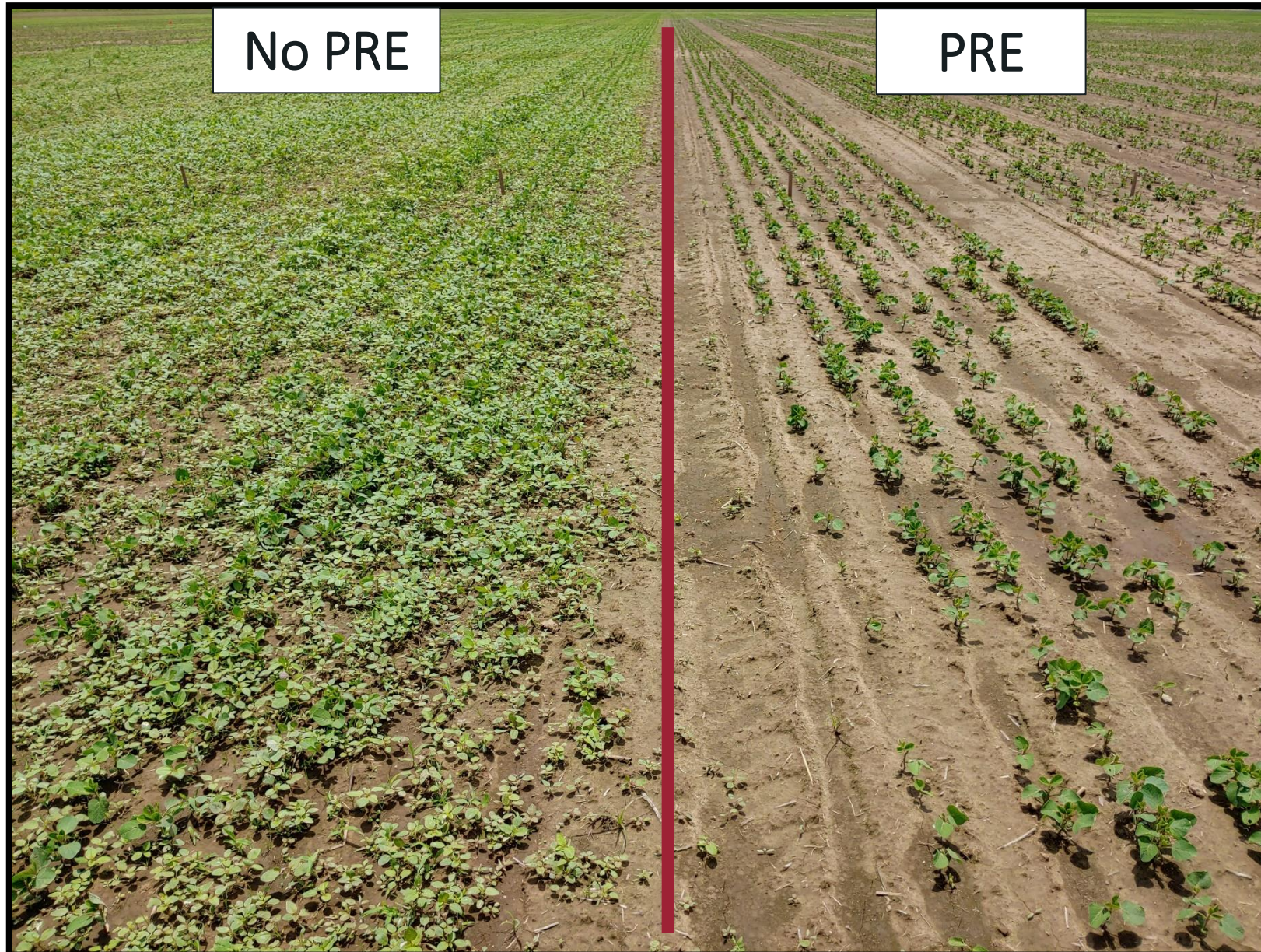
- **Multiple, diverse integrated weed management strategies**
 - Multiple, effective modes-of-action/tank-mixing
 - Optimize spray applications
 - Clean tillage/harvest equipment
 - Enhance crop competitiveness
 - Effectively implement and utilize new technologies
 - Weed seedbank management

PRE Herbicide Use

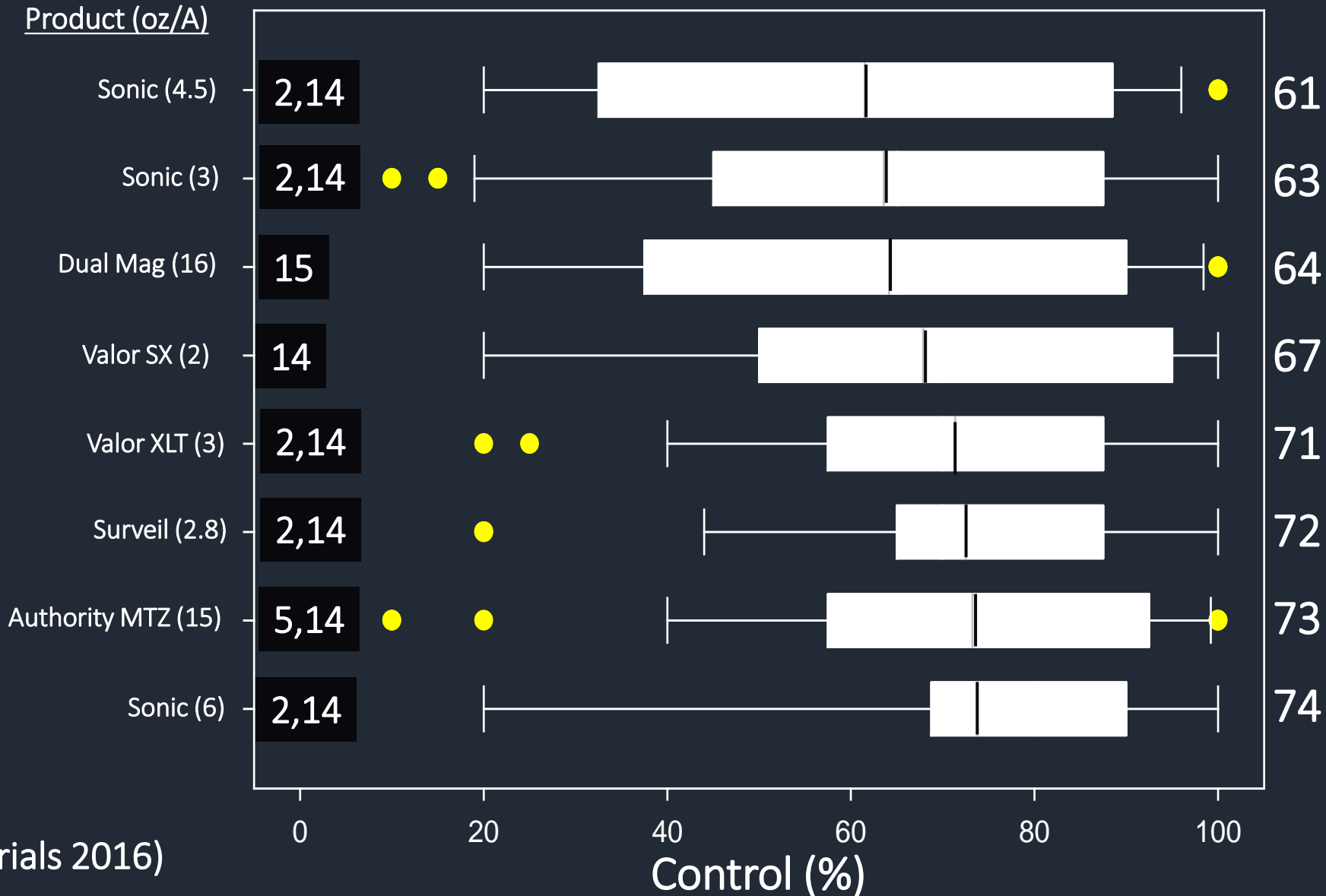
- Alternate herbicide sites-of-action
 - Reduces selection pressure for evolution of herbicide resistance
- PRE residual herbicides
 - Reduce number of weeds exposed to postemergence (POST) herbicide
 - Reduce early-season weed competition
 - Provide flexibility



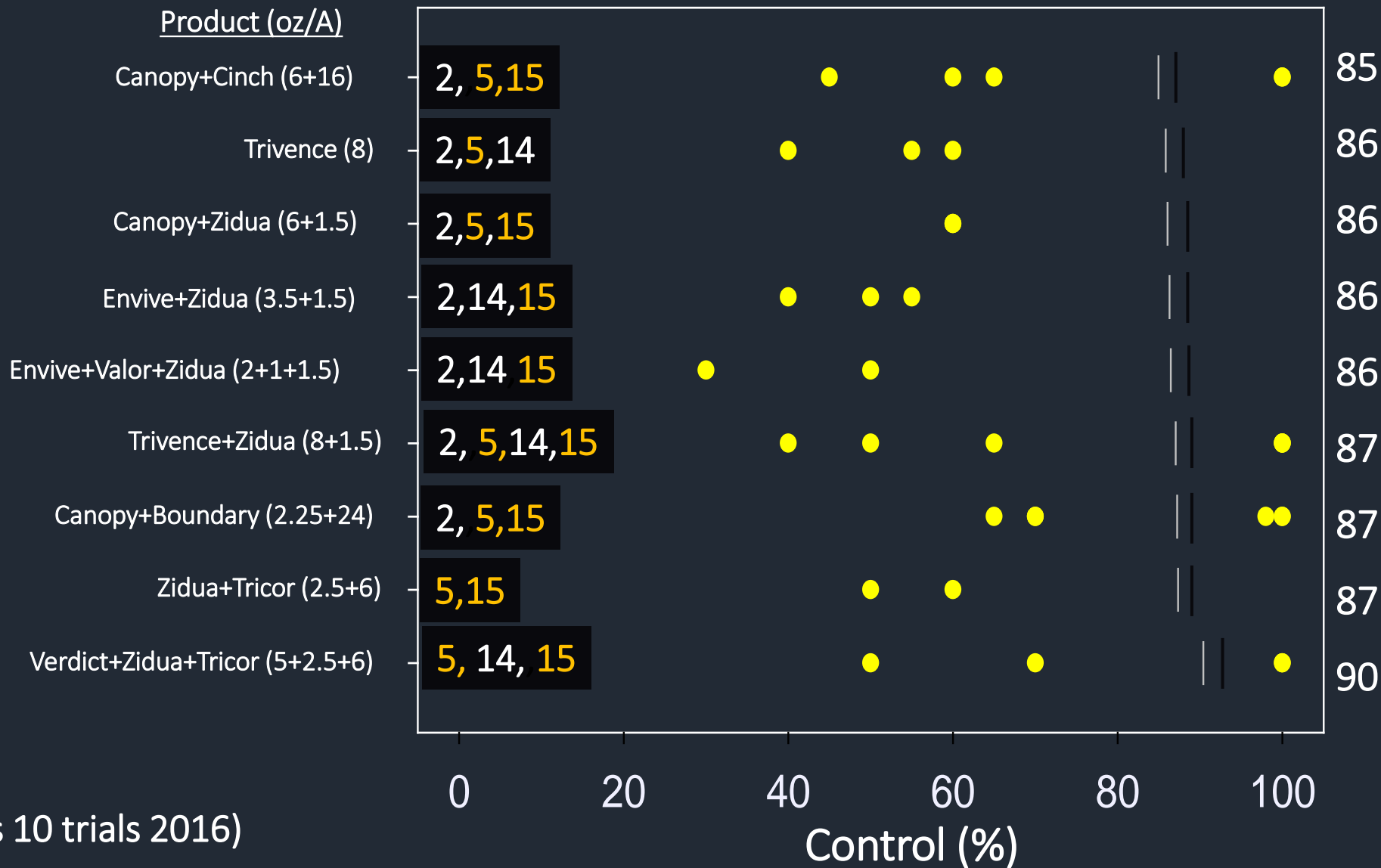
PRE Herbicide Use



PRE Programs on PPO- & VLCFA-Resistant Palmer Amaranth (26 to 28 DAT)



PRE Programs on PPO- & VLCFA-Resistant Palmer Amaranth (26 to 28 DAT)



Preemergence Residuals!

Photos taken 35 days after application

- Multiple, effective sites-of-action are needed
- Group 15's and metribuzin are extremely important for pigweed control



Photos taken 21 days
after final application



Control



Enlist One + Roundup
PowerMax + Liberty



Enlist One + Roundup
PowerMax + Moccasin
fb Liberty



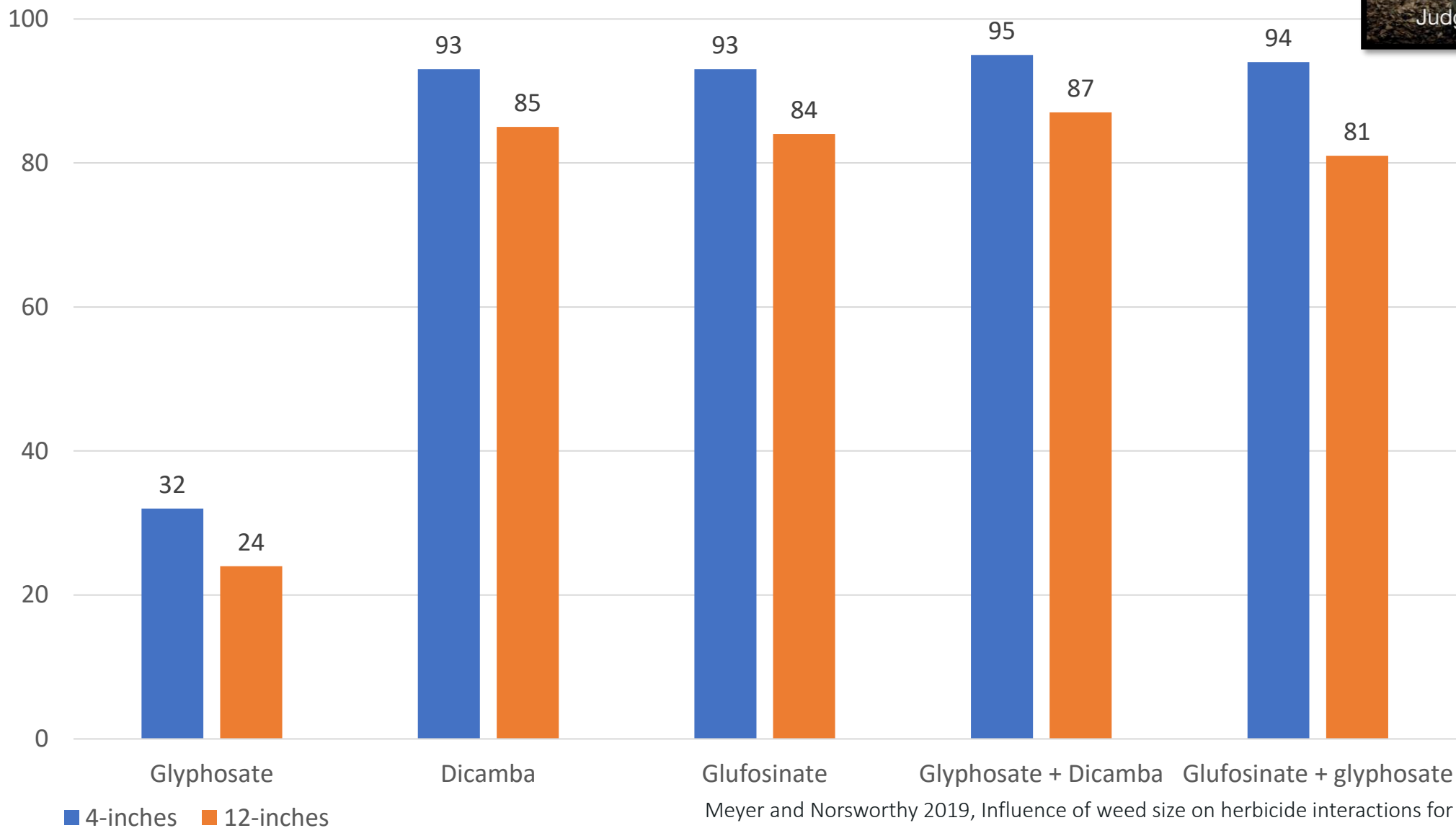
Enlist One + Roundup
PowerMax fb Enlist One



Enlist One + Roundup
PowerMax fb Liberty

Enlist E3 Recs & Overlapping Residuals

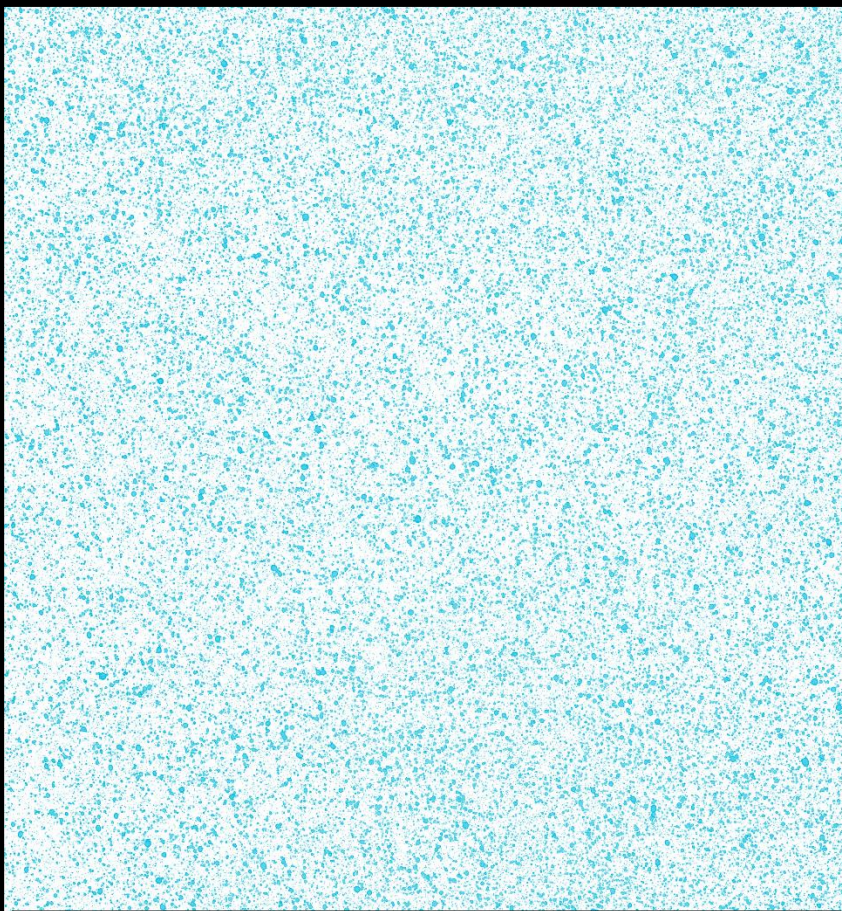
Weed Size Effect on Control



Meyer and Norsworthy 2019, Influence of weed size on herbicide interactions for Enlist and Roundup Ready Xtend technologies, *Weed Technology*, 33 (4): 569-577.

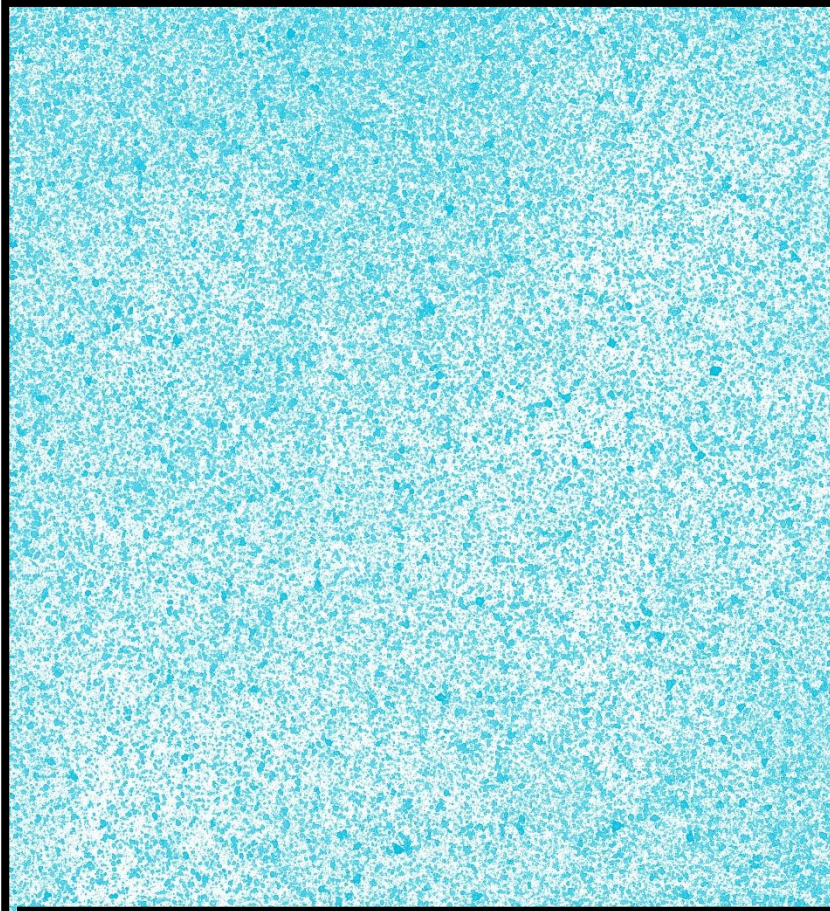


Spray Coverage (XR nozzle)



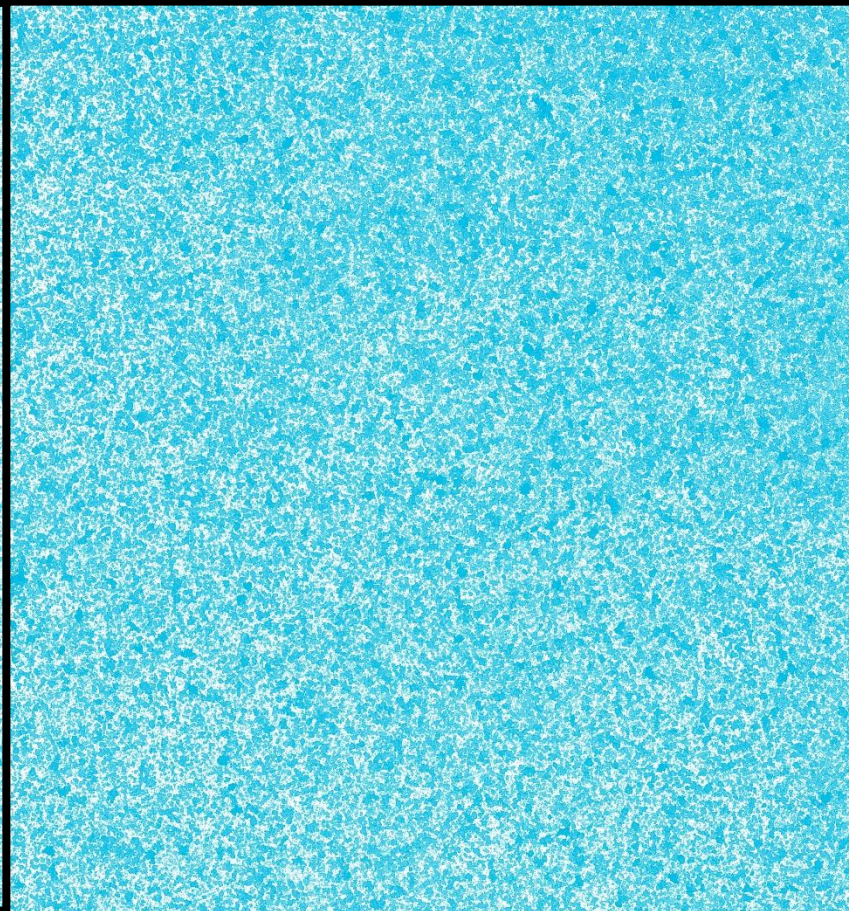
XR – 5 GPA

Droplet size	Spray Classification	Coverage
280 μm	Medium	19.9 %



XR – 10 GPA

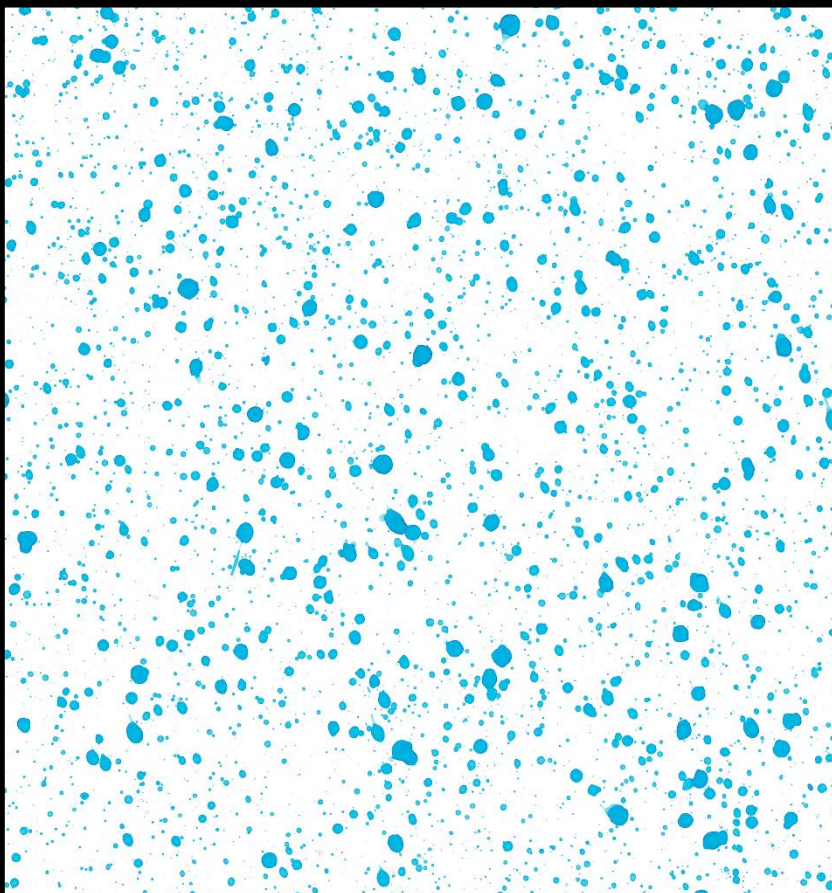
Droplet size	Spray Classification	Coverage
280 μm	Medium	42.7 %



XR – 15 GPA

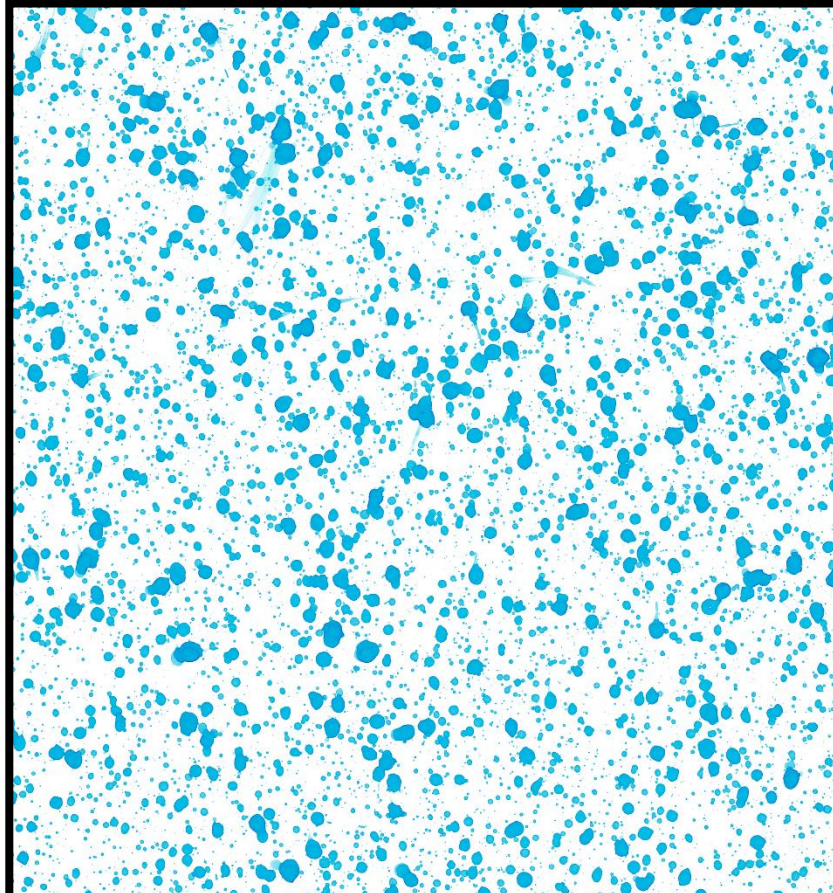
Droplet size	Spray Classification	Coverage
280 μm	Medium	64.5 %

Spray Coverage (TTI nozzle)



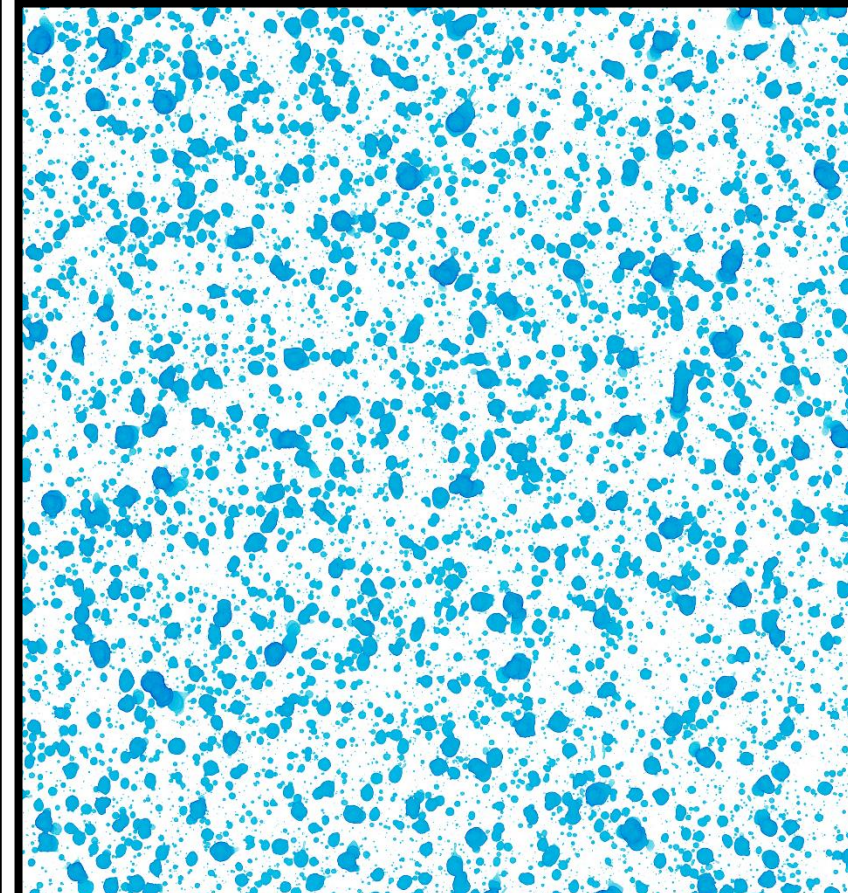
TTI – 5 GPA

Droplet size	Spray Classification	Coverage
800 μ m	Ultra Coarse	9.7 %



TTI – 10 GPA

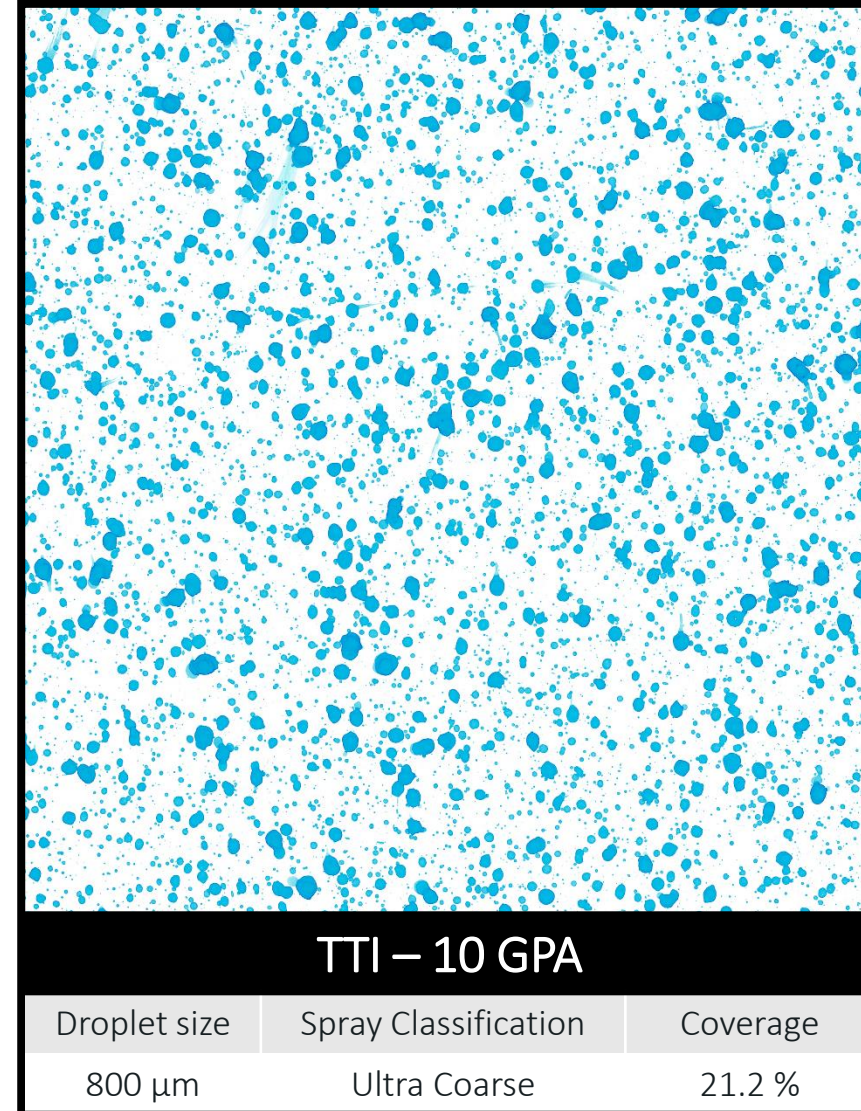
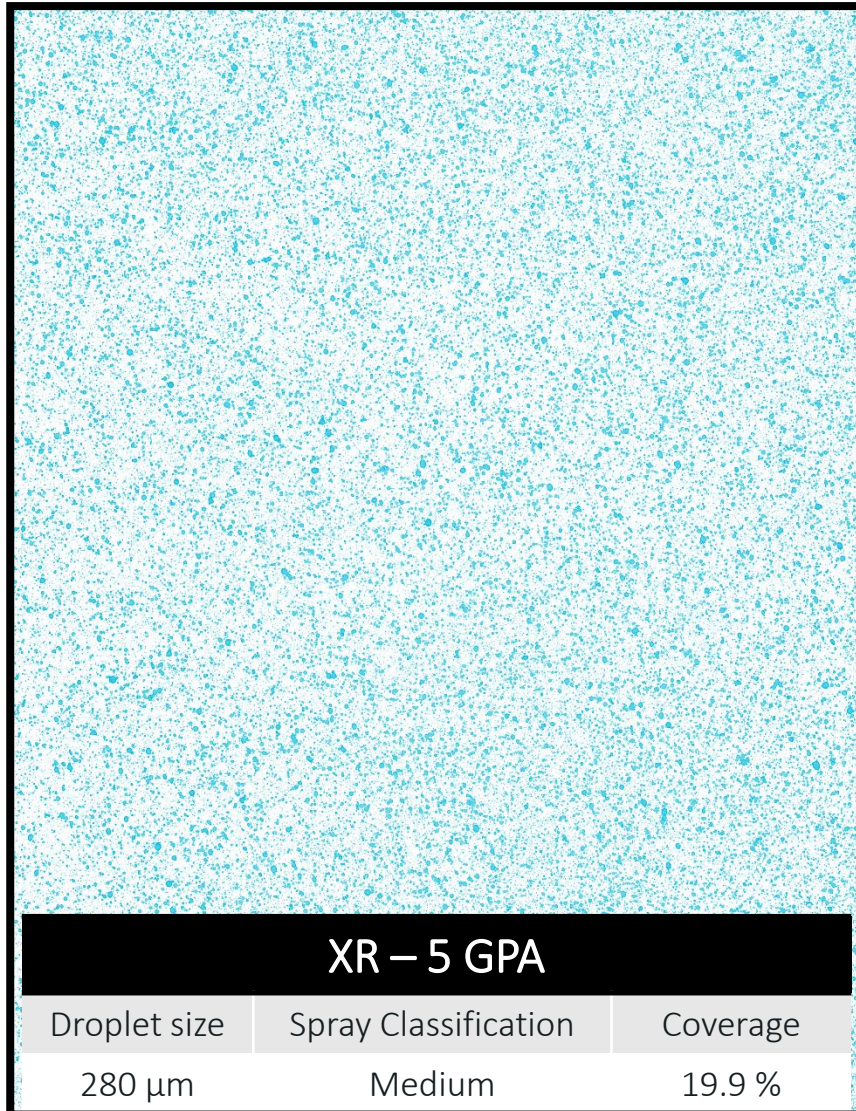
Droplet size	Spray Classification	Coverage
800 μ m	Ultra Coarse	21.2 %



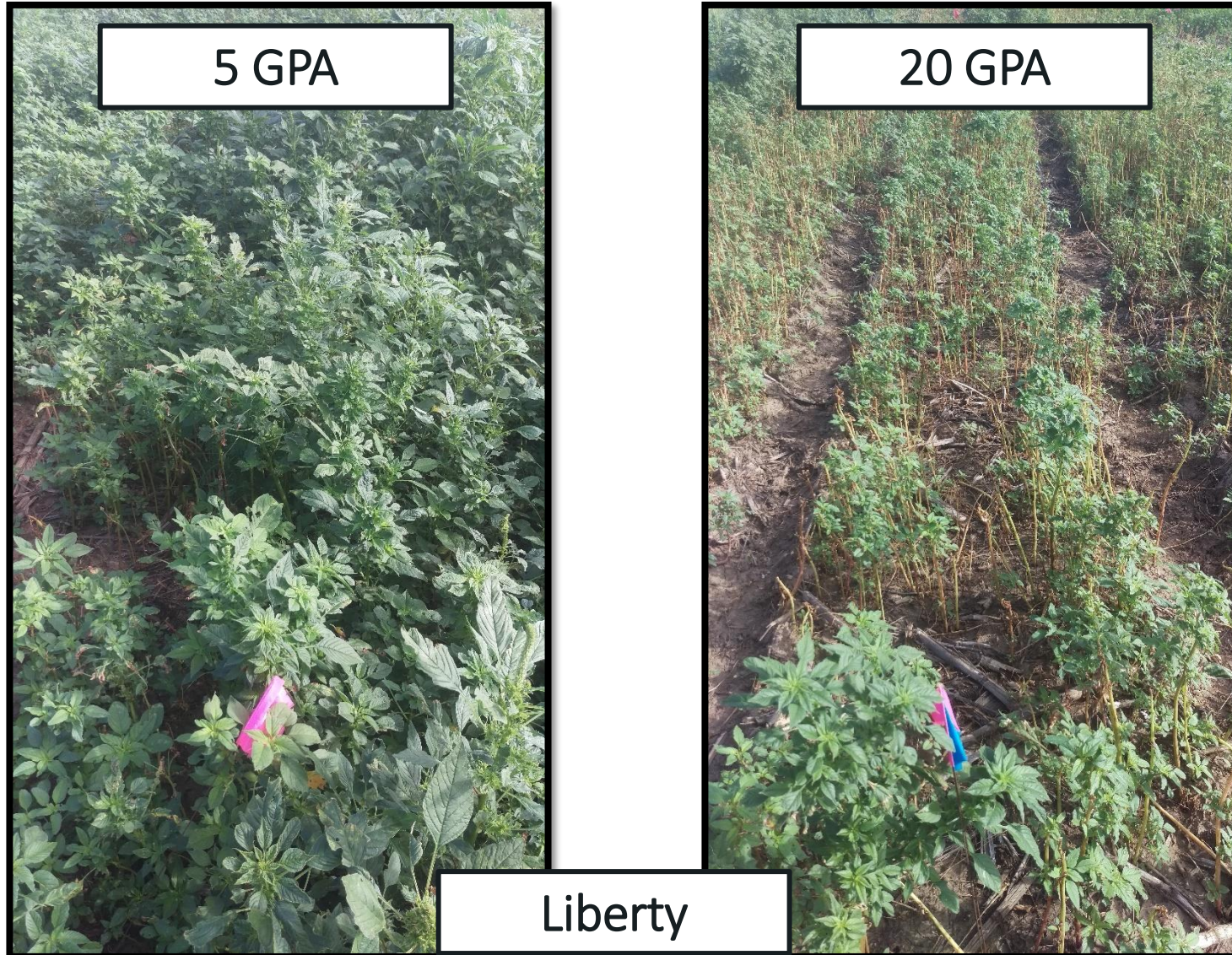
TTI – 15 GPA

Droplet size	Spray Classification	Coverage
800 μ m	Ultra Coarse	30.6 %

Spray Coverage (Comparison)



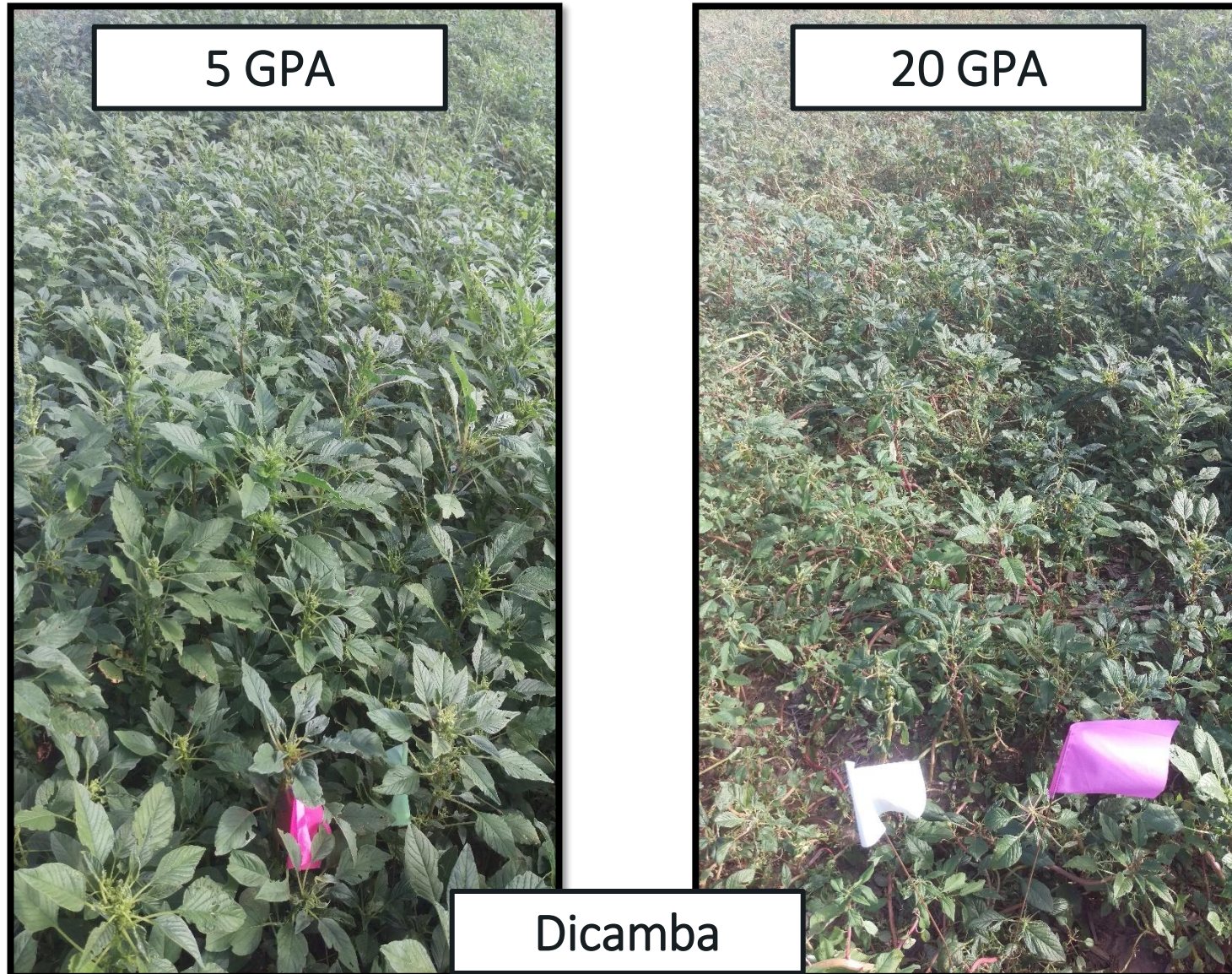
Spray Volume Effect on Weed Control



Butts et al. 2018, Spray droplet size and carrier volume effect on dicamba and glufosinate efficacy, *Pest Management Science*, 74 (9): 2020-2029.



Spray Volume Effect on Weed Control



Butts et al. 2018, Spray droplet size and carrier volume effect on dicamba and glufosinate efficacy, *Pest Management Science*, 74 (9): 2020-2029.

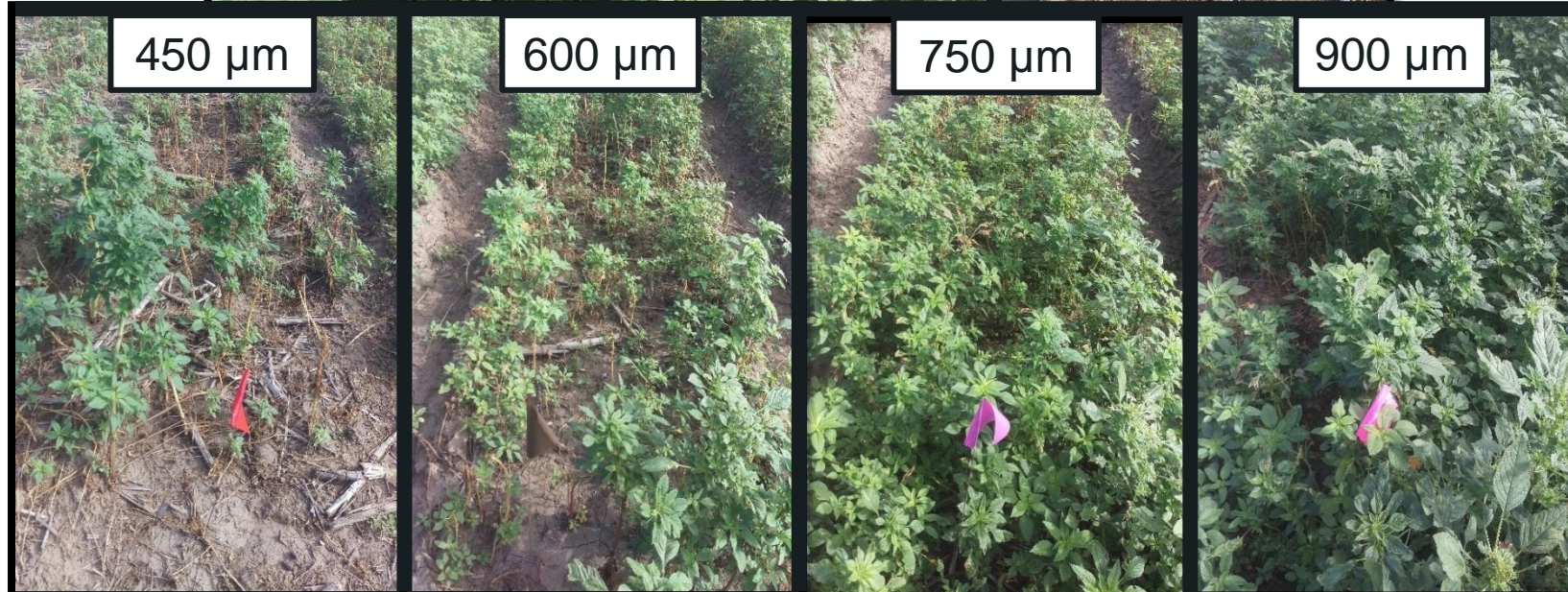
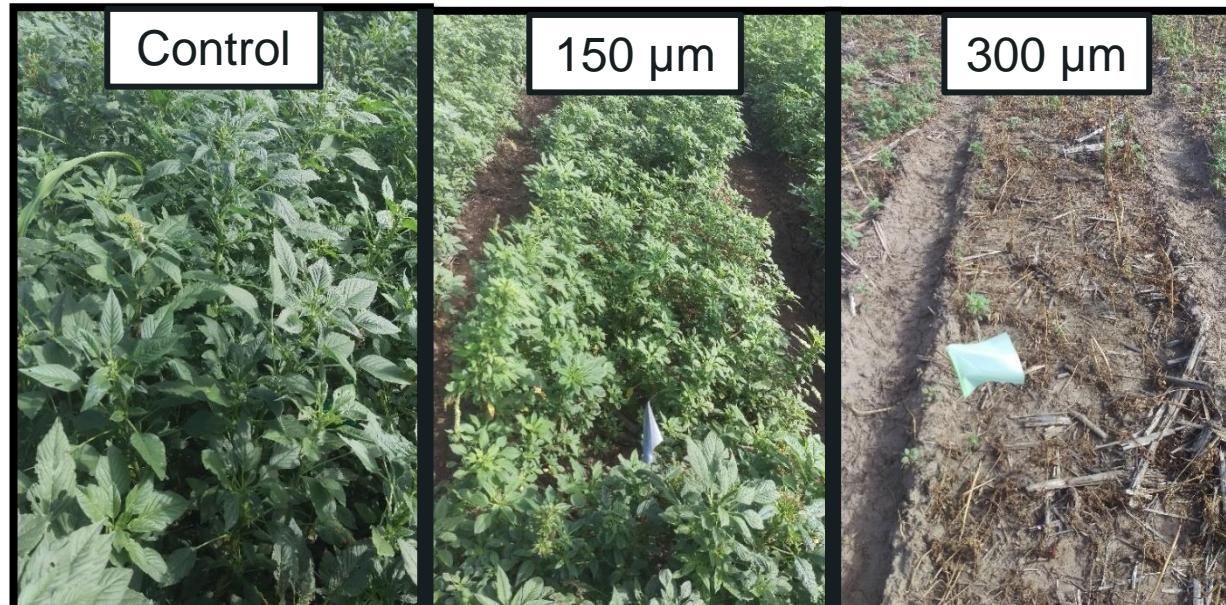


Droplet Size Effect on Weed Control

Liberty[®]

5 GPA

14 DAA



Butts et al. 2018, Spray droplet size and carrier volume effect on dicamba and glufosinate efficacy, *Pest Management Science*, 74 (9): 2020-2029.

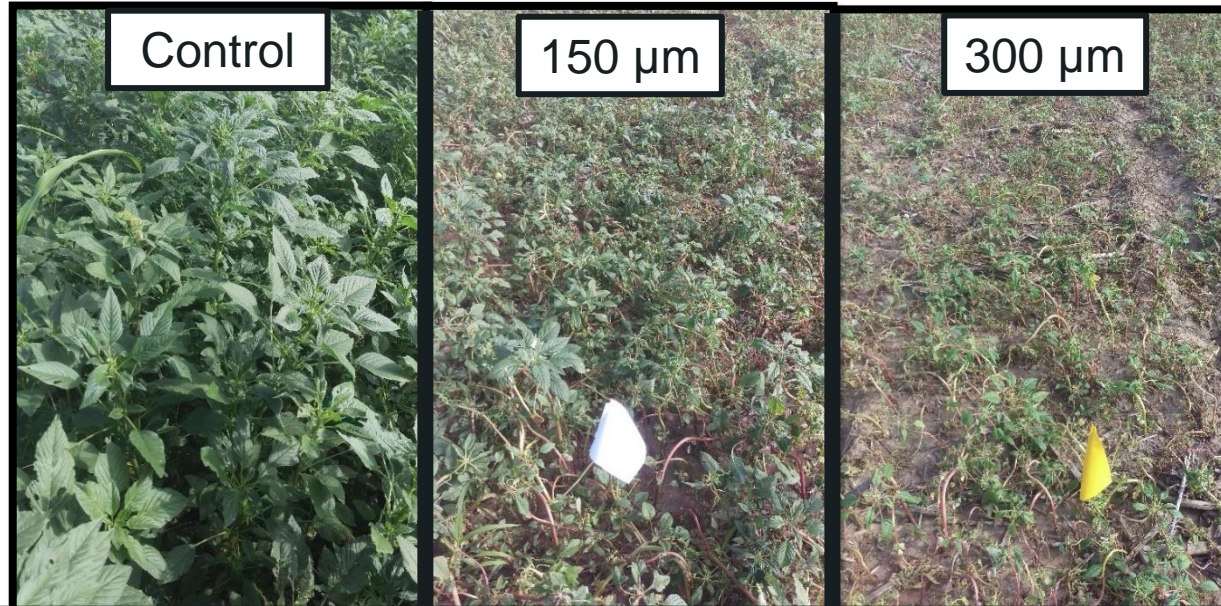


Droplet Size Effect on Weed Control

Dicamba

5 GPA

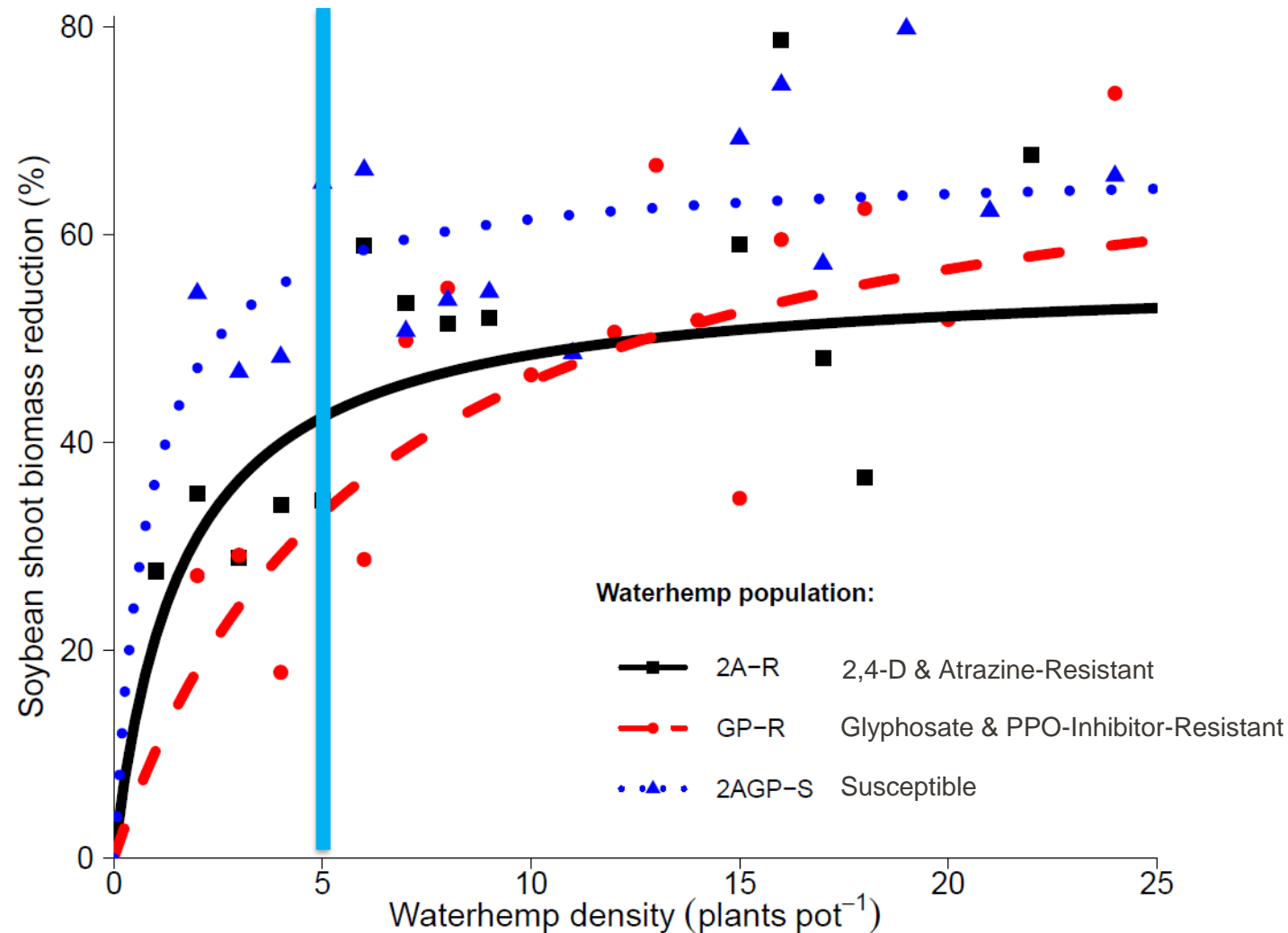
14 DAA



Butts et al. 2018, Spray droplet size and carrier volume effect on dicamba and glufosinate efficacy, *Pest Management Science*, 74 (9): 2020-2029.



Enhancing Crop Competitiveness



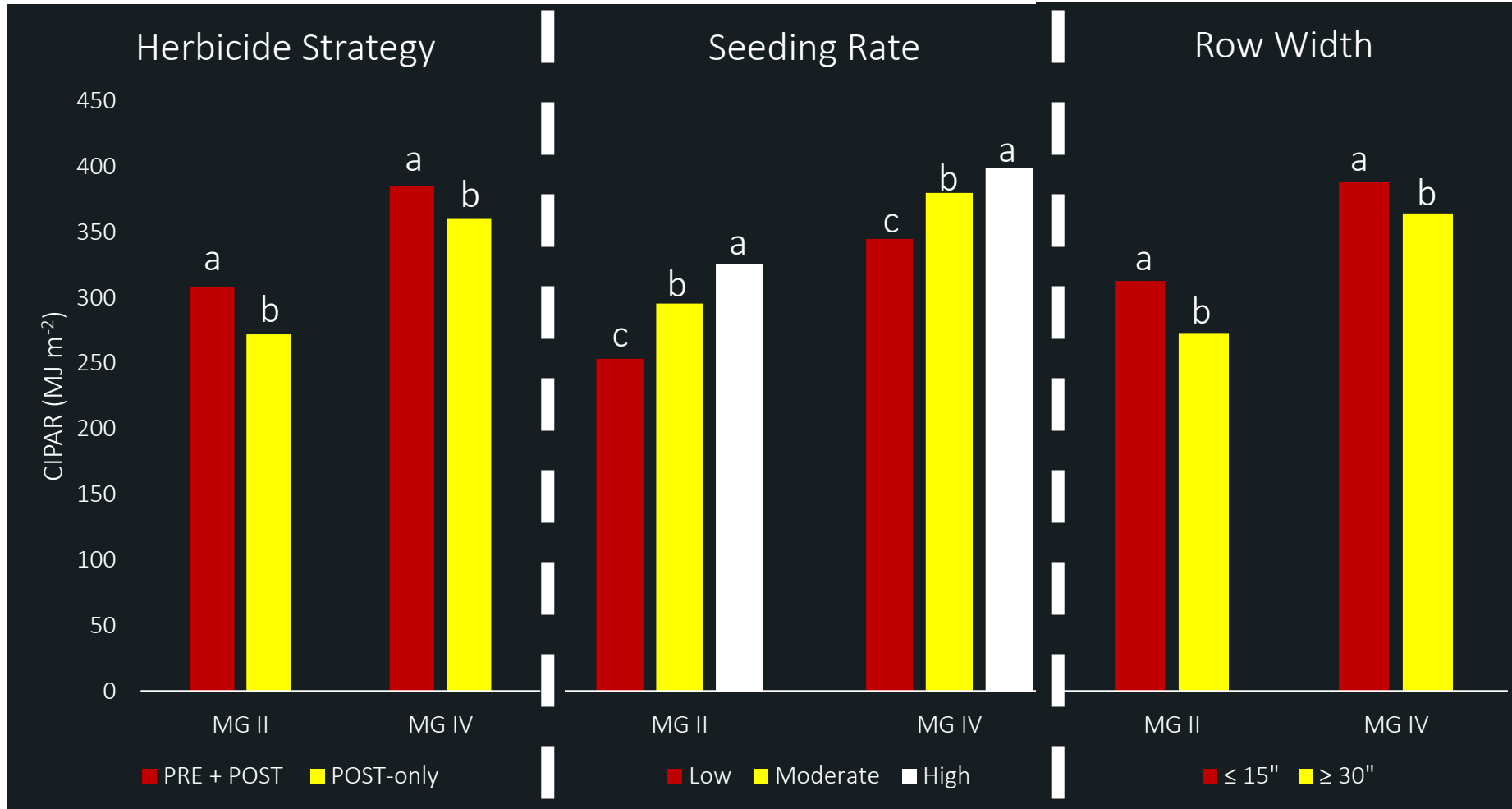
Adapted from:

Butts et al., 2018. Competitiveness of herbicide-resistant waterhemp (*Amaranthus tuberculatus*) with soybean. *Weed Sci* 66(6):729-737. DOI: 10.1017/wsc.2018.45



Soybean CIPAR

MG II and MG IV Regions



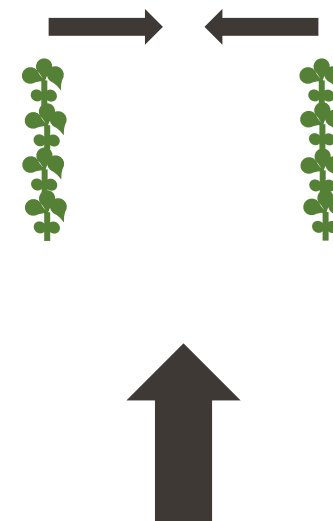
Adapted from:

Butts et al., 2016, Management of Pigweed in Glufosinate-Resistant Soybean in the Midwest and Mid-South, Weed Technology, 30 (2): 355-365.



Pigweed Seed Production

	MG II + III	MG IV
Factor	Seed	Seed
	seeds m ⁻²	seeds m ⁻²
Row width		
≤ 15"	10 a	22 a
≥ 30"	17 a	62 b
Seeding rate (seeds ac ⁻¹)		
70,000	--	57 b
130,000	--	51 b
190,000	--	17 a
Herbicide strategy		
PRE + POST	1 a	17 a
POST-only	123 b	78 b



2 is better than 1!

Adapted from:

Butts et al., 2016, Management of Pigweed in Glufosinate-Resistant Soybean in the Midwest and Mid-South, Weed Technology, 30 (2): 355-365.



Equipment Cleanout & a Community Problem

1. Necessary to clean tillage and harvest equipment thoroughly to stop the spread.
2. We all need to work **together** as a community to combat weed problems...



Harvest Weed Seed Destruction



Some wind needed

>400 C

Complete control of all weed seed

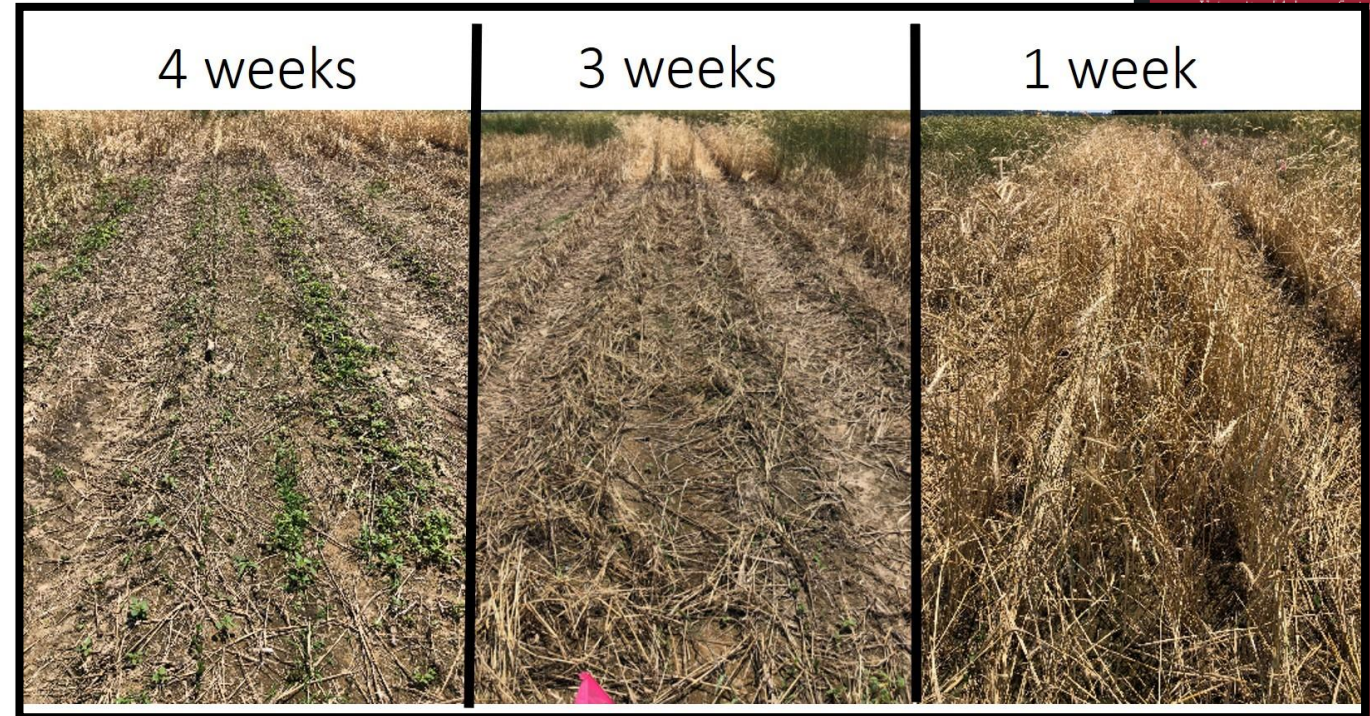


Twin Mill RedeKop™ Seed Destructor Installed on JD S680



Other Integrated Weed Management Strategies

- Cover crops
- Tillage:
 - Deep tillage (>6 inches) can bury seeds
 - Buries seeds deeper in the soil profile than they can emerge from (typical emergence comes from top 2 inches)
 - Should only occur every 4-5 years (otherwise, weed seeds will still be viable)



SPORTS Weed Control Extension Campaign

Start clean

Preemergence herbicides

Overlap residuals

Required: IWM tactics [crop rotation, seed prevention, tillage, etc.]

Timely

Selection of multiple, effective site-of-action herbicides

<https://bit.ly/UAEX-SPORTS>

A colorful poster for the "SPORTS" weed control campaign. At the top, the word "SPORTS" is in large, bold, red letters with a black outline. Below it, a list of strategies is written in bold black text: "START CLEAN", "PREEMERGENCE HERBICIDES", "OVERLAP RESIDUALS", "REQUIRED: IWM TACTICS", "TIMELY", and "SELECTION OF MULTIPLE, EFFECTIVE SITE-OF-ACTION HERBICIDES". To the right of the text is a cartoon illustration of a green weed character with a face, wearing a brown baseball cap and holding a brown baseball bat. The weed is standing on a brown baseball field base. In the background, two cartoon farmers, "FARMER JOHN" (number 20) and "FARMER JANE" (number 21), are wearing red baseball caps and white jerseys with red pinstripes. They are standing on a green field. A text box in the middle of the poster says: "Discuss SPORTS and other weed control strategies with your County Extension Agent, and pick up the MP44 Recommended Chemicals for Weed and Brush Control for the latest in Extension weed control recommendations to help STRIKE OUT Palmer amaranth and other tough-to-control weeds." Below this text box is a QR code and the text "VIEW THE MP44 ONLINE". At the bottom, the University of Arkansas Division of Agriculture Research & Extension logo is shown, along with the "AR WEED SCIENCE" logo and the website "www.uaex.uada.edu/weeds".

SPORTS

START CLEAN
PREEMERGENCE HERBICIDES
OVERLAP RESIDUALS
REQUIRED: IWM TACTICS
TIMELY
SELECTION OF MULTIPLE, EFFECTIVE SITE-OF-ACTION HERBICIDES

Discuss SPORTS and other weed control strategies with your County Extension Agent, and pick up the MP44 Recommended Chemicals for Weed and Brush Control for the latest in Extension weed control recommendations to help STRIKE OUT Palmer amaranth and other tough-to-control weeds.

VIEW THE MP44 ONLINE

U of A
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

AR WEED SCIENCE

www.uaex.uada.edu/weeds

The University of Arkansas System Division of Agriculture is an Equal Opportunity Institution. All persons are encouraged to participate in all programs and services without regard to race, color, sex, gender, identity, sexual orientation, national origin, religion, age, disability, marital status, veteran status, genetic information, or any other legally protected status, and/or an otherwise discriminatory basis or pretext.



Other Information

Visit our website -> <https://www.uaex.uada.edu/weeds>

MP544

**HERBICIDE RESISTANCE TRAITS:
Quick Reference Guide**

This quick reference guide was established to provide a direct resource to quickly identify what herbicides each herbicide-resistant trait and the respective herbicides that those traits confer resistance to. (Table 3) and soybean (Table 4) and corn (Table 5). A check mark and green box indicate that the trait is paired with the specified herbicide and does not injure the respective crop.

Herbicide-resistant crops have provided more flexibility for postemergence (POST) herbicide applications across cropping systems. Today, there are more options than ever before for herbicide-resistant traited technology leading to an abundant number of potential POST tank-mixture combinations. However, this abundance of options has led to confusion of which herbicides certain traits confer resistance to and has increased the potential for misapplications to occur.

CORN HERBICIDE TRAIT	GLYPHOSATE	GLUFOSINATE
CONVENTIONAL		
GLYPHOSATE TOLERANT (GT)	✓	✓
LIBERTYLINK (LL)	✓	✓
GT LL	✓	✓
ROUNDUP READY 2 YIELD (RR2Y)	✓	✓
RR2Y LL	✓	✓
ENLIST	✓	✓

*TRAITS LISTED AS CORN (Agrisure, Optum, YieldGuard, SmartStax, etc.) often refer to the latest trait resistance trait within those products, please consult the product information provided by the company for approved 3,4-D choline formulations (Enlist Duo, Enlist One) are permitted to be applied on corn.

Agriculture and Natural Resources

PSA2188

**Distribution and Management of
Herbicide-Resistant Palmer Amaranth
in Arkansas**

Introduction
Palmer amaranth (*Amaranthus palmeri* S. Watson) is a highly competitive, annual broadleaf weed that has been listed as one of the most troublesome weeds in multiple agricultural production systems in Arkansas (Wychen 2019). The prolific growth characteristics of Palmer amaranth are what make it one of the most adaptable and challenging weed species for farmers to manage.

Seeds are very small (1-2 mm diameter), black, and shiny (G. and are easily dispersed by wind, water, livestock feed, and equipment (Legleiter and Johnson 2013, et al. 2013). Upwards of 1,500 seeds have been produced by a single Palmer amaranth plant (Figure 1). Palmer amaranth forms C4 photosynthesis which

for its increased growth rates (up to

Thomas R. Bufta
Assistant Professor -
Extension Weed Scientist

L. Tom Barber
Professor - Extension
Weed Scientist

Jason K. Norsworthy
Distinguished Professor -
Weed Science

MP44

**Arkansas 2021
Recommended Chemicals
for Weed and Brush Control**

See MP44 online at www.uaex.edu
Cooperative Extension Service, University of
Arkansas System, U.S. Department of Agriculture
and County Governments Cooperating

U of A
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

AR
WEED
SCIENCE

<http://bit.ly/HRTraitsGuide>

<https://bit.ly/Palmer-Resistance-Management>

<http://bit.ly/UAEX-MP44>

Other Information

Visit our website -> <https://www.uaex.uada.edu/weeds>



SCAN ME

<http://bit.ly/UAEXHerbSymptoms>

Get weed control updates
directly on your phone.

Opt-in to our UAEX Field Crop
Extension Specialist Text Service!

Text “**weeds**” to (501) 300-8883.



Weeds AR Wild podcast series on
Arkansas Row Crops Radio

- Weekly episode
- <https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/RowCropsRadio.aspx>

Acknowledgements



University of Arkansas Weed Science Group

Arkansas Rice Research and Promotion Board

Arkansas Soybean Promotion Board

United Soybean Board, Take Action

USDA-NIFA CPPM Grant Award No. 2020-70006-32981

USDA-ARS, Aerial Application Technology Unit

Wilger, Inc.

Capstan Ag

Industry Collaborators



National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE





Thank you! Questions?



National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE



DIVISION OF AGRICULTURE
RESEARCH & EXTENSION

University of Arkansas System

Dr. Tommy Butts
Extension Weed Scientist
(501) 804-7314



✉ tbutts@uada.edu
🔗 uaex.uada.edu/weeds
🐦 [@weedsARwild](https://twitter.com/weedsARwild)