

# PPO-Resistant Palmer: Implications and Control

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# PIGWEEEDS!!!

Palmer

Smooth

Redroot

Slender



# Waterhemp and Palmer Amaranth!!!

## Target Sites Confirmed Resistant too:

- **Waterhemp:**
  - ALS, HPPD, PPO, EPSPS, PS II, Synthetic auxin
- **Palmer Amaranth:**
  - ALS, HPPD, PPO, EPSPS, PS II, Microtubule Inhibitor

Palmer

Slender

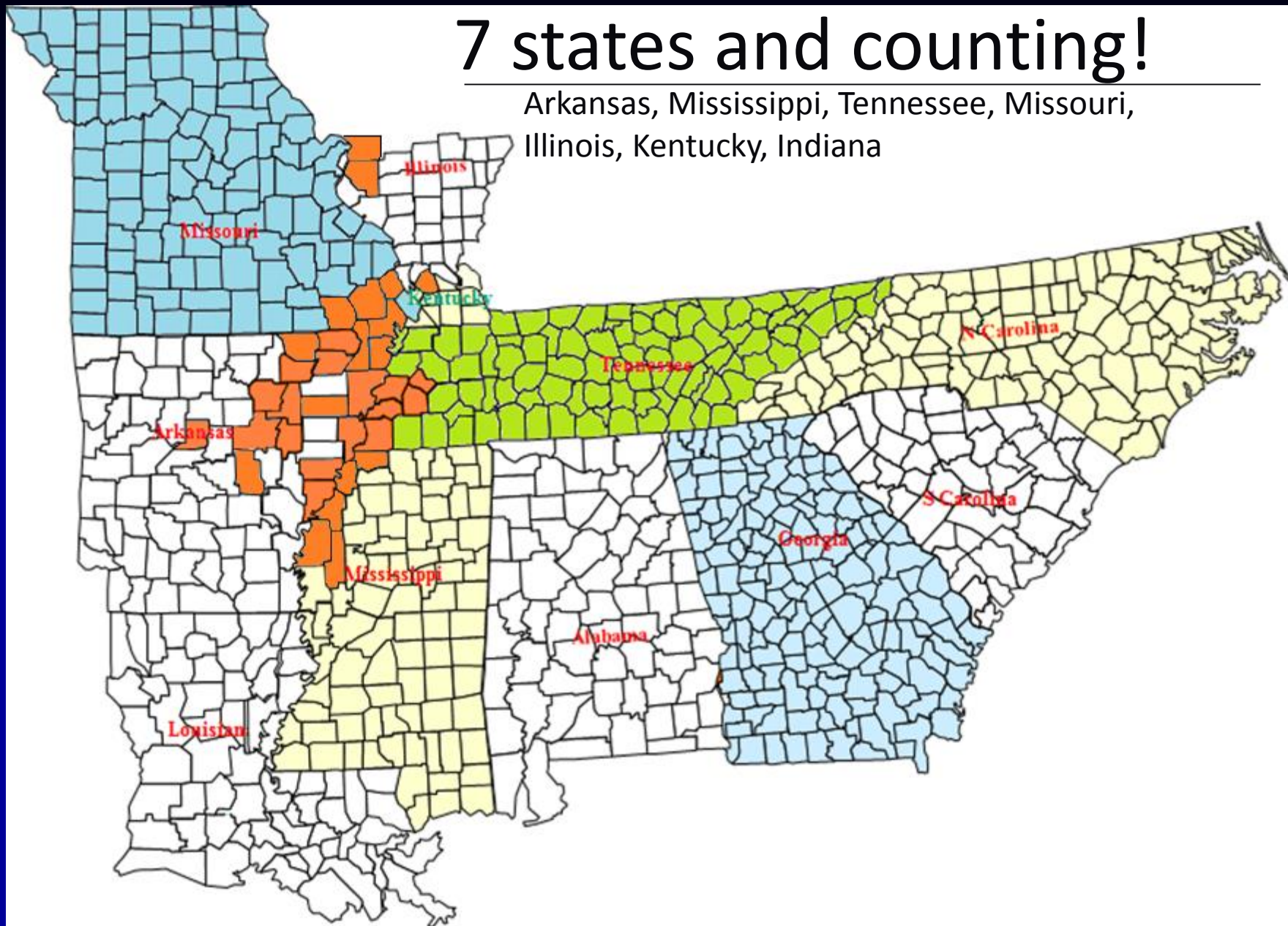
Smooth

Redroot

# PPO-Resistant Palmer amaranth

7 states and counting!

Arkansas, Mississippi, Tennessee, Missouri,  
Illinois, Kentucky, Indiana



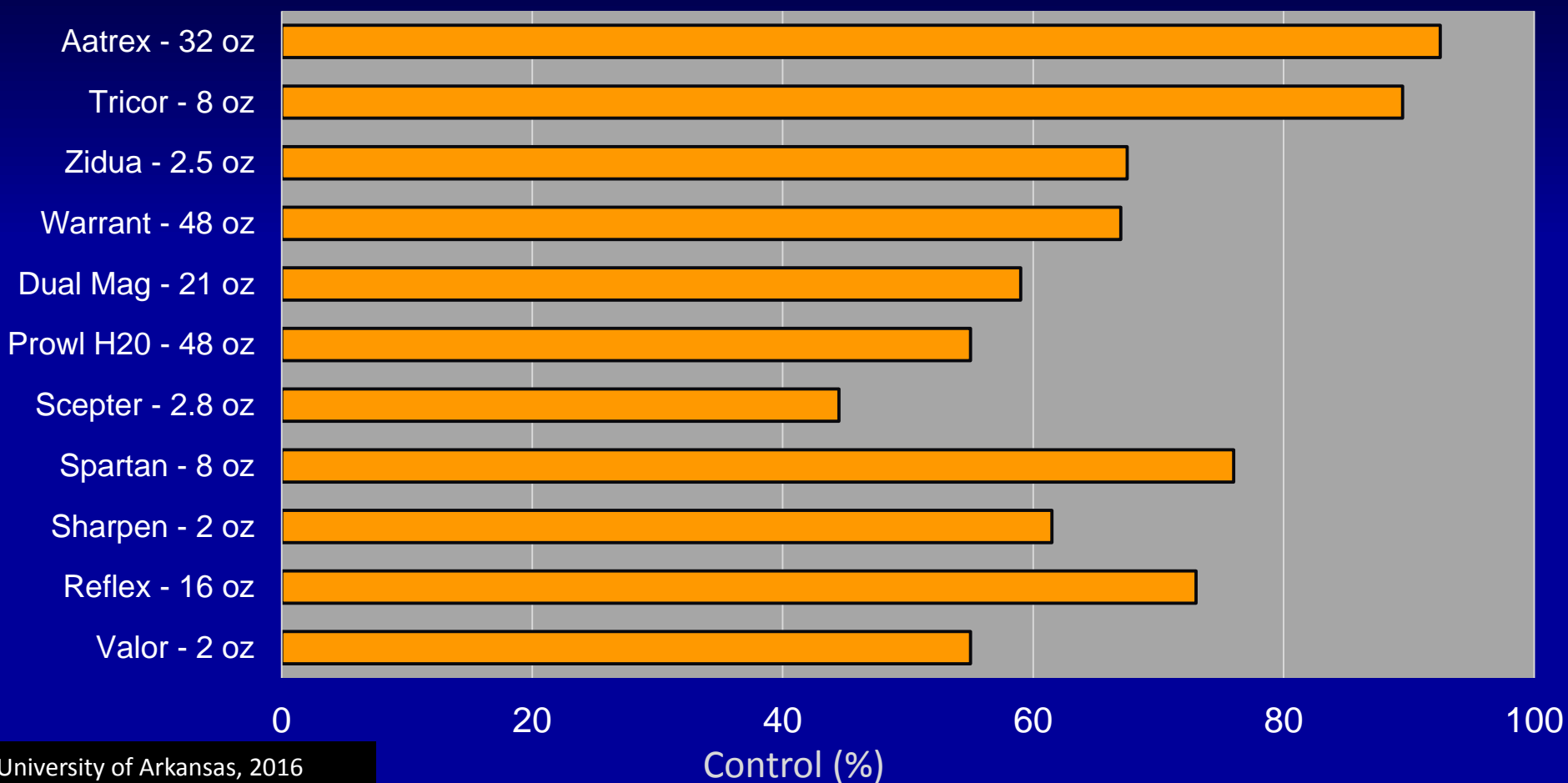
# PPO-Resistant Pigweed

## Response to PRE Herbicides

14 days after treatment

■ Crawfordsville + Marion (Average)

LSD(0.05) 17

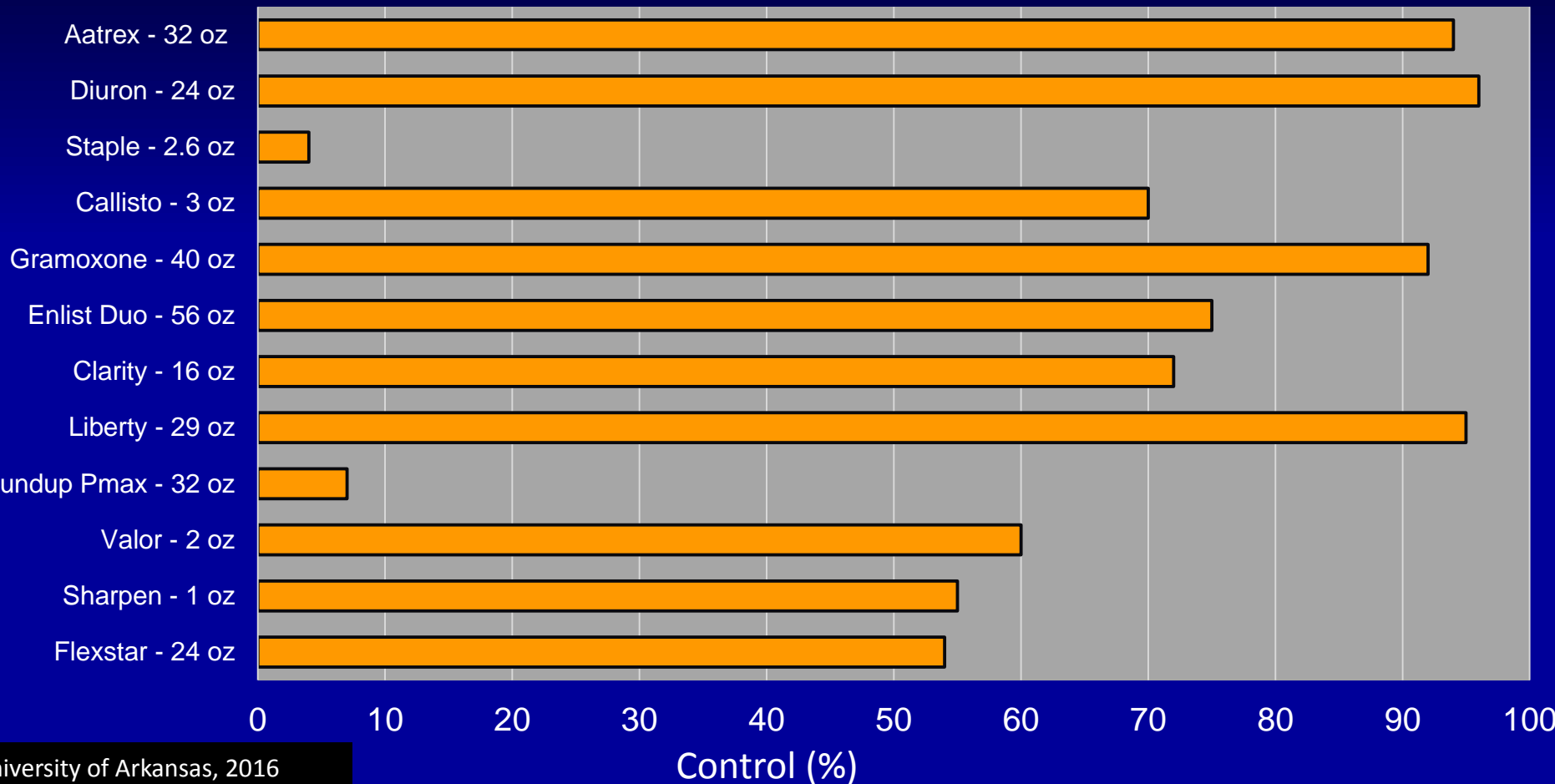


# PPO-Resistant Pigweed Response to POST Herbicides

13 to 19 days after treating 1- to 6-inch plants

■ Crawfordsville (Avg of 2 trials)

LSD(0.05) 18



**1 to 4 inch pigweed;  
13 DAT**

1.5 pt/A Flexstar  
1% v/v COC

Nontreated

**14 days after treatment**



**32 oz/A Roundup PowerMax**



**29 oz/A Liberty**



**16 oz/A Clarity**



**4.75 pt/A Enlist Duo**



# Programs Targeting PPO-R Palmer Amaranth

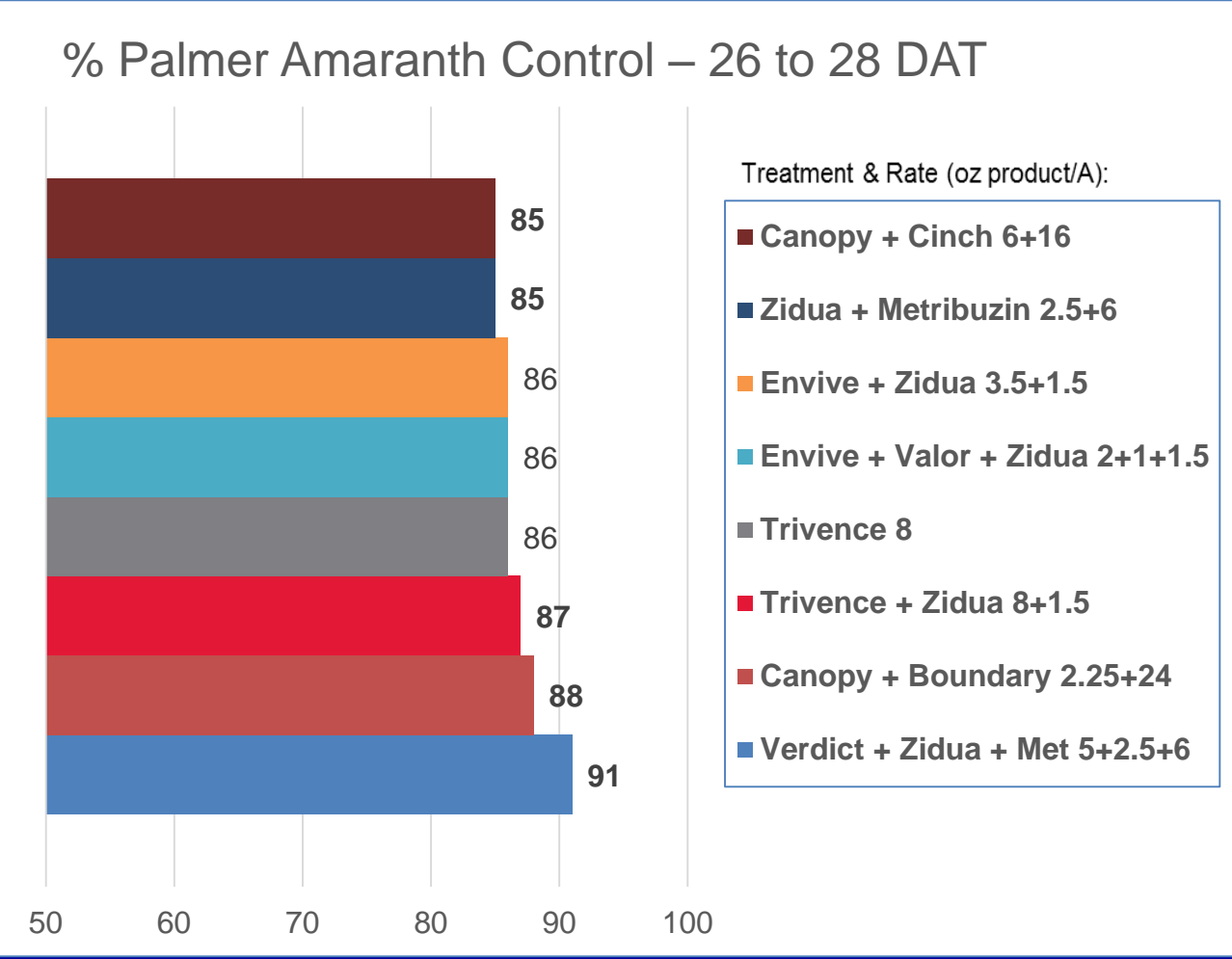
University of Arkansas Preemergence Treatments				
Company:	Treatment:	Rate: (oz product/A)		# Trials
DuPont	Envive	3.5	Pre	10
DuPont	Envive +Zidua	3.5 + 1.5	Pre	10
DuPont	Envive + Valor	2 + 1	Pre	10
DuPont	Envive + Valor + Zidua	2 + 1 + 1.5	Pre	10
DuPont	Canopy + Cinch	6 + 16	Pre	10
DuPont	Canopy + Zidua	6 + 1.5	Pre	10
DuPont	Canopy + Boundary	2.25 + 24	Pre	10
DuPont	Trivence	8	Pre	10
DuPont	Trivence + Zidua	8 + 1.5	Pre	10
Syngenta	Boundary	24	Pre	10
Syngenta	Dual Magnum	16	Pre	10
Valent	Valor SX	2	Pre	10
Valent	Valor XLT	3	Pre	10
Valent	Fierce	3.75	Pre	10
Valent	Fierce XLT	4.5	Pre	10
FMC	Authority Elite	22	Pre	10
FMC	Authority MTZ	15	Pre	10
BASF	Zidua + Metribuzin	2.5 + 6	Pre	10
BASF	Verdict + Zidua + Metribuzin	5 + 2.5 + 6	Pre	10
Dow	Sonic	3	Pre	10
Dow	Sonic	4.5	Pre	10
Dow	Sonic	6	Pre	7
Dow	Surveil	2.8	Pre	10
Dow	Surveil	4.2	Pre	10
---	Metribuzin	8	Pre	7
---	Metribuzin + Dual Magnum	8 + 21	Pre	7
---	Untreated Check	---	---	0

- University of Arkansas - 2016  
Programs for control of PPO-R Palmer Amaranth
  - 3 locations - 10 trials total
    - Dr. Tom Barber – Marion, AR (3)
    - Dr. Jason Norsworthy – Crawfordsville, AR (4)
    - Dr. Bob Scott – Gregory, AR (3)
  - PPO-R confirmed in 2015 @ locations
  - Same Preemergence Trts (10 trials) –fb-  
different post technologies
    - Roundup Ready – 3
    - Liberty Link – 3
    - Xtend – 2
    - Enlist – 2
  - All trials received adequate rainfall for  
activation of residual herbicides
  - Post applications applied at 26-28 days after  
planting, 4-8” pigweed

University of Arkansas, 2016  
(Drs. Barber, Norsworthy & Scott)

# Programs Targeting PPO-R Palmer Amaranth

Preemergence treatments that averaged 85% control or greater:



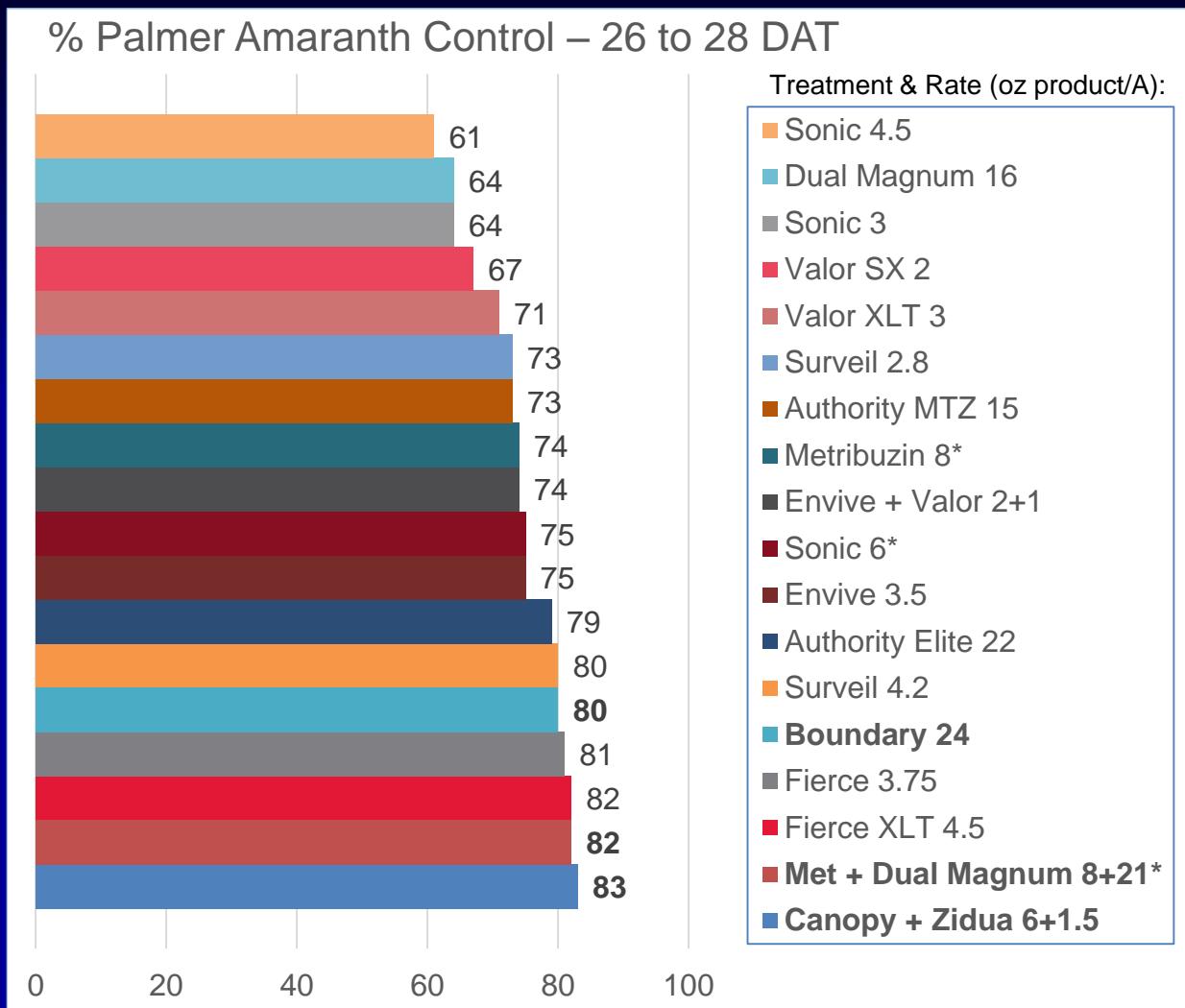
### Treatments with 2 effective MOA's:

1. Canopy + Cinch 6+16 oz/A
2. Zidua + Metribuzin 2.5+6 oz/A
3. Trivence + Zidua 8+1.5 oz/A
4. Canopy + Boundary 2.25+24 oz/A
5. Verdict + Zidua + Metribuzin 5+2.5+6 oz/A

(Average of 10 trials)

# Programs Targeting PPO-R Palmer Amaranth

Preemergence treatments that averaged less than 85% control:



## Treatments with 2 effective MOA's:

1. Boundary 24 oz/A
2. Metribuzin + Dual Magnum 8+16 oz/A
3. Canopy® + Zidua 6+1.5 oz/A

(\* Average of 7 trials, all other treatments are an average of 10 trials)

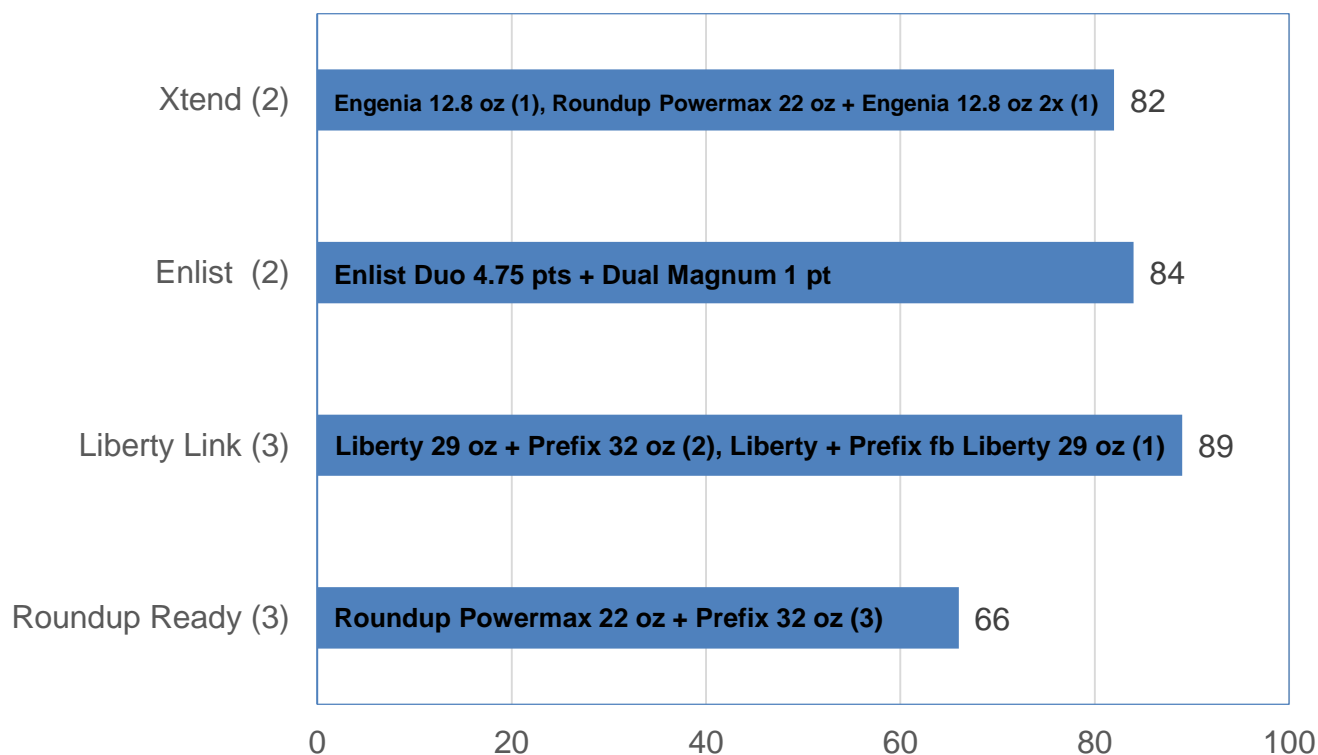
University of Arkansas, 2016  
(Dr. Barber, Norsworthy & Scott)

# Programs targeting PPO-R Palmer Amaranth

Final control following the post applications by technology.

Averaged across 8 preemergence trts with 85% control or > at post application:

% Palmer Amaranth Control – 28 to 42 DAT of POST



## Post applications:

- In order to separate the pre's, post applications were applied late, 26-28 DAP, 4-8" pigweed, average 6"
- With all technologies, must apply post by 21 DAP targeting 2" pigweed to be successful
- Multiple post applications may be required for full season control

# PPO Untreated Check Marion, AR





Boundary



Sonic

14 days after Engenia



Boundary



Valor XLT

14 days after Engenia



Boundary



Sonic

14 days after 2<sup>nd</sup> Engenia  
Application





Boundary



Sonic

28 days after 2<sup>nd</sup> Engenia  
Application



Dual Magnum

Valor XLT

14 days after 2<sup>nd</sup> Engenia  
Application



Fierce



Trivence + Zidua

14 days after 2<sup>nd</sup> Engenia  
Application



**2 oz Valor PRE fb 2 apps  
Engenia 12.8oz POST**



**16 oz Dual PRE fb 2 apps  
Engenia 12.8 oz POST**



**24 oz Boundary PRE  
2 apps Engenia 12.8oz POST**



**2.5oz Zidua + 6 oz Metribuzin PRE fb**  
**2 apps Engenia 12.8oz**

# Palmer Management Strategies for 2017

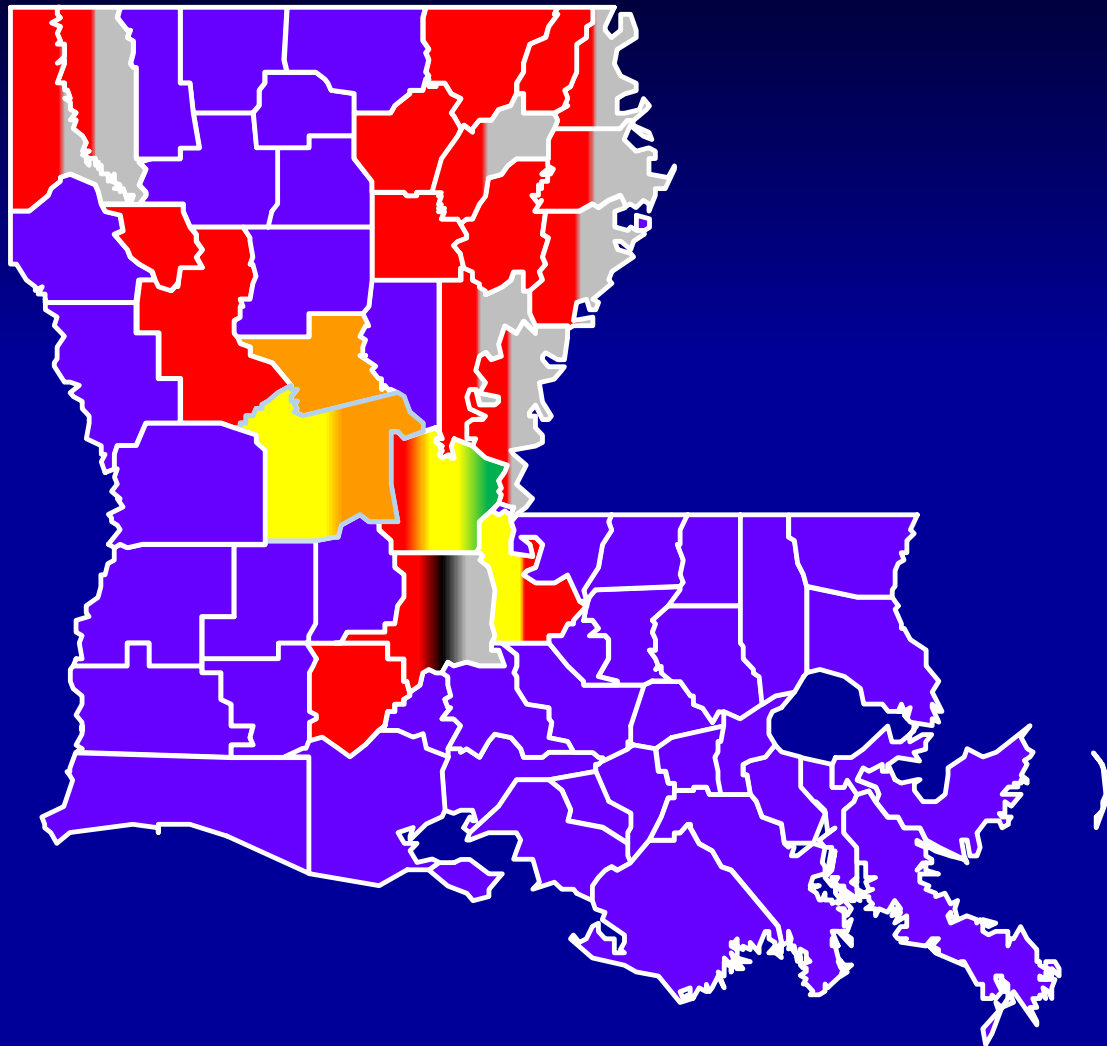




# Implications For LA Growers



- Confirmed Herbicide Resistance
  - glyphosate
    - Red = Palmer amaranth
    - Orange = waterhemp



# PPO Resistance

Technology	Preplant	Preplant/PRE	POST over-the-top
Roundup Ready	Pendimethalin trifluralin	<del>Authority Elite / BroadAxe; Authority MTZ;</del> Boundary; <del>Valor; Valor XLT; Fierce; Sonic /</del> <del>Authority First; Envive;</del> Zidua; Canopy + Dual Magnum	glyphosate + Dual Magnum or Zidua; <del>glyphosate + Prefix,</del> <del>Flexstar GT 3.5; glyphosate +</del> <del>Cobra; Flexstar/Reflex; Ultra</del> <del>Blazer; or Classic</del>
Liberty Link	Pendimethalin trifluralin	<del>Authority Elite / BroadAxe; Authority MTZ;</del> Boundary; <del>Valor; Valor XLT; Fierce; Sonic /</del> <del>Authority First; Envive;</del> Zidua; Canopy + Dual Magnum	Liberty + Dual Magnum or Zidua, <del>Liberty + Prefix; Liberty + Cobra;</del> <del>Flexstar/Reflex; Ultra Blazer; or</del> Classic
Conventional	Pendimethalin trifluralin	<del>Authority Elite / BroadAxe; Authority MTZ;</del> Boundary; <del>Valor; Valor XLT; Fierce; Sonic /</del> <del>Authority First; Envive;</del> Zidua; Canopy + Dual Magnum	<del>Cobra; Flexstar/Reflex; Prefix;</del> <del>Ultra Blazer; or Classic</del>

- If PPO herbicides are lost, we'd have to rely upon....
- Boundary, Zidua, Canopy, Liberty, and Metribuzin for weed management

# Management Strategies

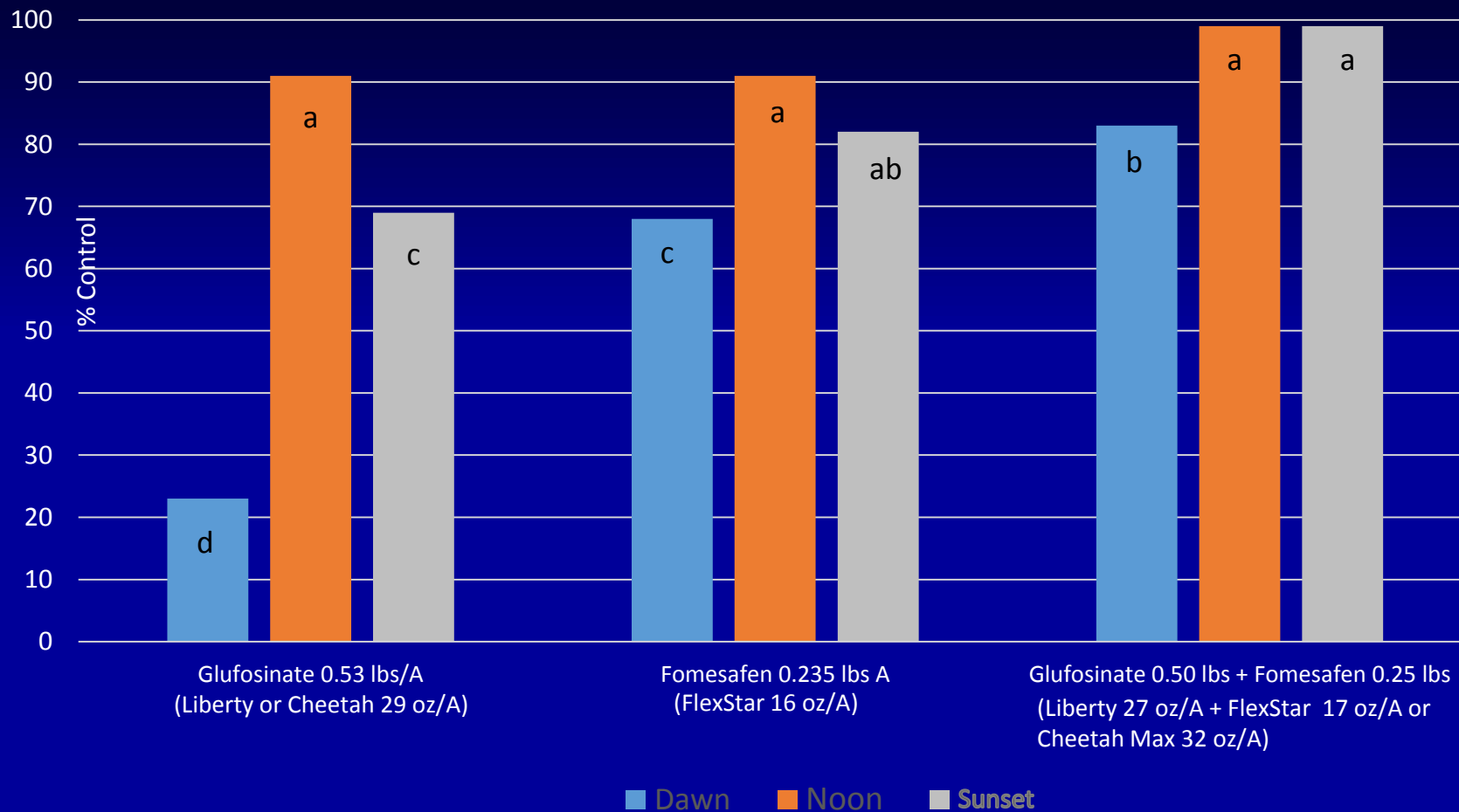
## Reduce PPO Selection Pressure

- Avoid using PPO herbicides in Corn and Cotton production
- In Soybean – Avoid PPO at-planting fb PPO POST
- Technology Rotation: Plant Liberty Link Crops
  - Need 3 herbicide modes of action to protect/delay Liberty resistance
- Take advantage of new herbicide technologies
  - Residuals will remain as important as ever regardless of herbicide technology trait being used

# Time of Day Affect on PPO-Susceptible Palmer Amaranth Population 2015.

## Application to 4" Palmer

Ratings taken 13 DAA



# Applied 12 to 16" tall Palmer amaranth



LIBERTY 280 2.34 SL  
29 fl oz/a Sunrise +1hr

Applied to 12 to 16" tall Palmer amaranth

LIBERTY 280 2.34 SL  
29 fl oz/a Sunrise +1hr  
FLEXSTAR 1.88 SL  
16 fl oz/a Sunrise +1hr  
MSO L  
1 % v/v Sunrise +1hr

**Applied to 12 to 16" tall Palmer amaranth**

**LIBERTY 280 2.34 SL**  
**29 fl oz/a Noon**



# Applied to 12 to 16" tall Palmer amaranth

LIBERTY 280 2.34 SL  
29 fl oz/a Sunrise +1hr  
COBRA 2 EC  
10 fl oz/a Sunrise +1hr  
MSO L  
1 % v/v Sunrise +1hr

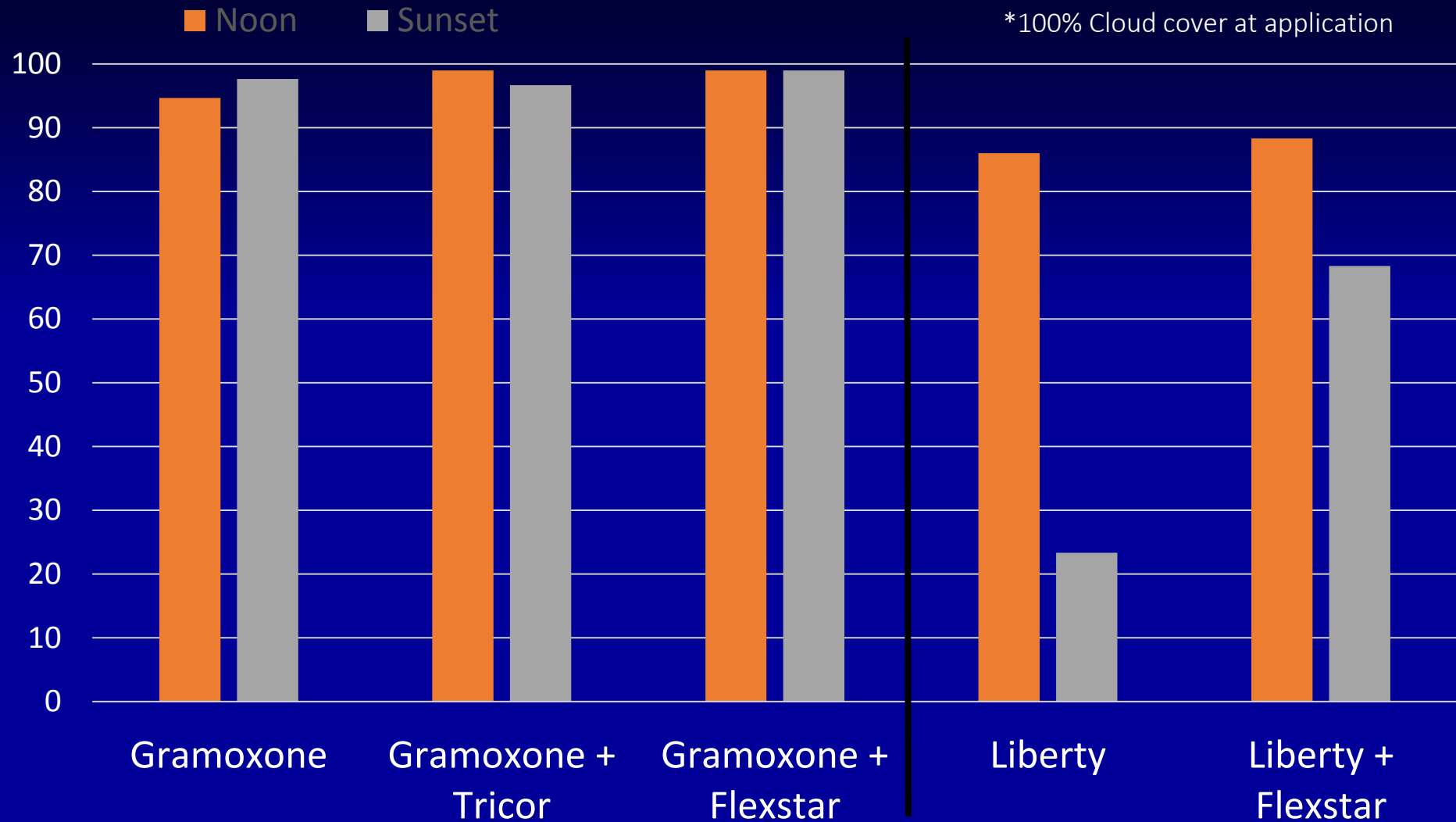


# Applied to 12 to 16" tall Palmer amaranth

**LIBERTY 280 2.34 SL**  
**29 fl oz/a Noon**  
**FLEXSTAR 1.88 SL**  
**16 fl oz/a Noon**  
**MSO L**  
**1 % v/v Noon**



# 20% PPO Resistant Palmer Control 7 DAT



# Herbicide Resistant Weed Mgmt.

- Burndown
  - Considering using DNAs 4-6 wks prior to planting
- Consider planting Liberty Link Crops
- At planting
  - paraquat plus
  - Metribuzin (tolerant varieties) w/ Dual, Zidua or Outlook
- Early-postemergence
- Mid-postemergence
- Directed
  - All get a non-selective plus residual herbicide
  - Apply Liberty with Flexstar in Liberty tolerant varieties
    - More consistent Palmer control
- Use Multiple MOA's per application



# Herbicide Resistance Weed Management Recommendations

- Reduce reliance on one herbicide; select herbicides with multiple modes of action and use full label rates and apply when label specifies ( $\leq 3''$ )
- Increase cultural control practices
  - Row spacing, increase seeding rates, altered planting date, tillage, etc...
- Manage the weed seedbank
  - Post-harvest weed control (deep tillage)
  - Control weed escapes
  - Zero tolerance to seed production
- Crop Rotation – Corn, Sorghum, Rice
- Incorporate high residue cover crops – Cereal rye
- Season long weed control will require multiple residual herbicides regardless of the technology system being utilized

# Questions?

## Special Thanks

**Drs. Tom Barber, Bob Scott, and Jason Norsworthy of U of A  
and Dr. Larry Steckle from the UT for their assistance**

**Have a Great Growing Season!!**