War Against Weeds in Kansas

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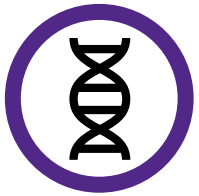
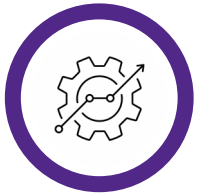
Outline

Driver weeds in KS



Metabolic herbicide resistance

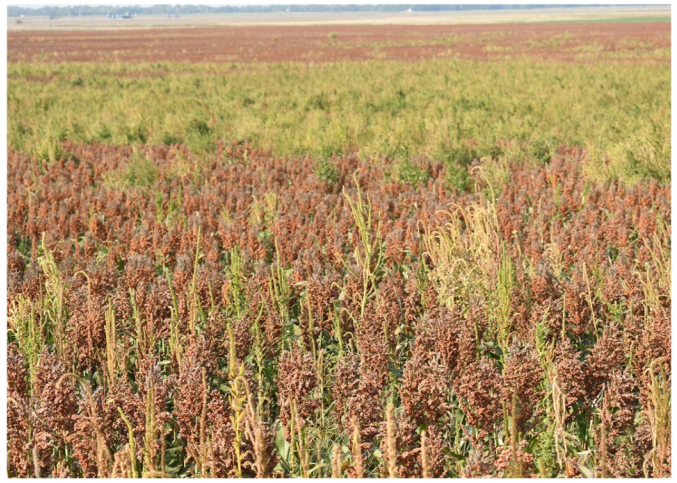


Optimizing herbicide applications

Targeted herbicide applications

Wheat/corn/sorghum/fallow
~1,500 A
14” - 20” annual precipitation

Wheat/corn/soybean/sorghum/cotton
~900 A
20” - 30” annual precipitation



Corn/soybean, pasture
~400 A
30” - 40” annual precipitation

Corn/soybean, pasture
40” - 51” annual precipitation

https://nassgeodata.gmu.edu/CropScape/

HERBICIDE RESISTANCE IN PALMER AMARANTH

Herbicide group (example herbicide)	Number of cases	Year (and state) of first report	Year of first report in KS
9, EPSPS inhibitor (glyphosate)	44	2005 (GA)	2011
2, ALS inhibitors (Beyond, Harmony, Glean, Pursu	25	1993 (KS)	1993
5, PSII inhibitors (atrazine, metribuzin)	11	1993 (TX)	1995
27, HPPD inhibitors (Callisto, Laudis, Impact)	7	2009 (KS)	2009
14, PPO inhibitors (Reflex, Cobra)	5	2011 (AR)	2021
4, Growth regulators (2,4-D, dicamba)	3	2015 (KS)	2015 (2,4-D) 2021 (dicamba)
15, VLCFA inhibitors (Dual, Harness, Outlook, Zidua)	2	2016 (AR)	Not yet
10, Glutamine synthetase inhibitor (Liberty)	2	2020 (AR)	Not yet

HERBICIDE RESISTANCE IN WATERHEMP

Herbicide group (example herbicide)	Number of cases	Year (and state) of first report	Year of first report in KS
9, EPSPS inhibitor (glyphosate)	27	2005 (MO)	2006
2, ALS inhibitors (Beyond, Harmony, Glean, Purs	27	1993 (IL, IA)	1995
5, PSII inhibitors (atrazine, metribuzin)	15	1994 (MO)	1995
14, PPO inhibitors (Reflex, Cobra)	12	2001 (KS)	2001
27, HPPD inhibitors (Callisto, Laudis, Impact)	6	2009 (IL)	Not yet
4, Growth regulators (2,4-D, dicamba)	3	2009 (NE)	Not yet
15, VLCFA inhibitors (Dual, Harness, Outlook, Zidua)	1	2016 (IL)	Not yet
10, Glutamine synthetase inhibitor (Liberty)			*2023*

HERBICIDE RESISTANCE IN KOCHIA

Herbicide group (example herbicide)	Number of cases	Year (and state) of first report	Year of first report in KS
2, ALS inhibitors (Glean)	20	1987 (KS)	1987
9, EPSPS inhibitor (glyphosate)	13	2007 (KS)	2007
5, PSII inhibitors (atrazine)	13	1976 (KS)	1976
4, Growth regulators (dicamba)	7	1994 (MT)	2013
14, PPO inhibitors (Valor, Sharpen, Authority)		2023 (ND)	Not yet

Herbicide resistance

Target-site

- One gene
- Develops faster

- Changed genetic code at one or more nucleotides
- Increased gene expression

Nontarget-site

- > 1 gene
- Creeping resistance
- Cross-resistance

- Altered absorption, translocation, sequestration
- Phoenix phenomenon
- *Enhanced herbicide metabolism*

Metabolic resistance

- Herbicide converted to inactive forms before plant is killed
  - Cytochrome P450s
    - Step 1: Add or remove small molecules
  - Glutathione S-transfersase
    - Step 2: Add large molecules

- Affected MOA Groups:
  - ACCase (1)
  - ALS (2)
  - PS II (5)
  - Glyphosate (9)
  - DXS (13)
  - PPO (14)
  - VLCFA (15)
  - HPPD (27)

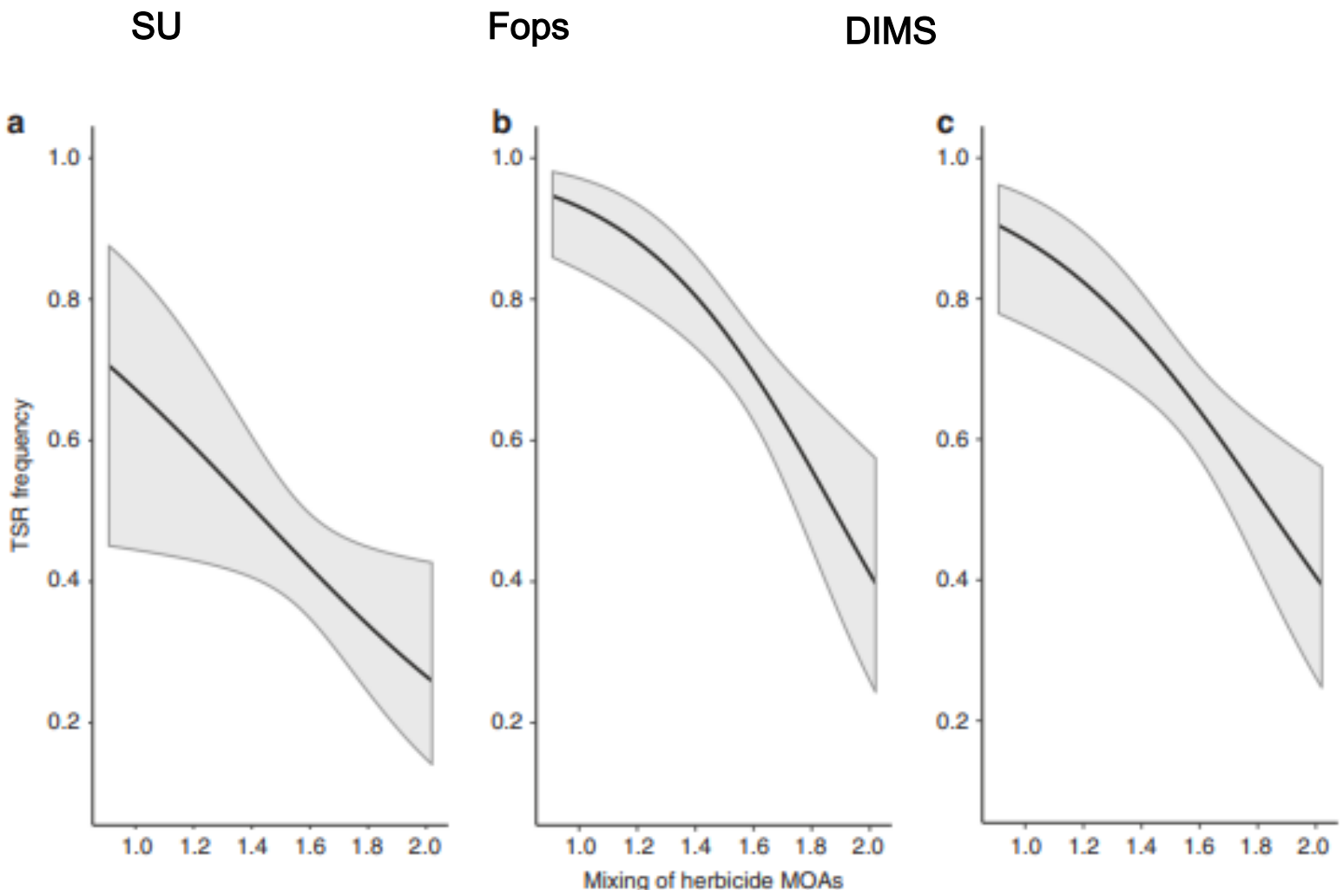
Shyam et al. 2019; *metabolic resistance

Metabolic resistance

We *must* rethink assumptions regarding herbicide resistance

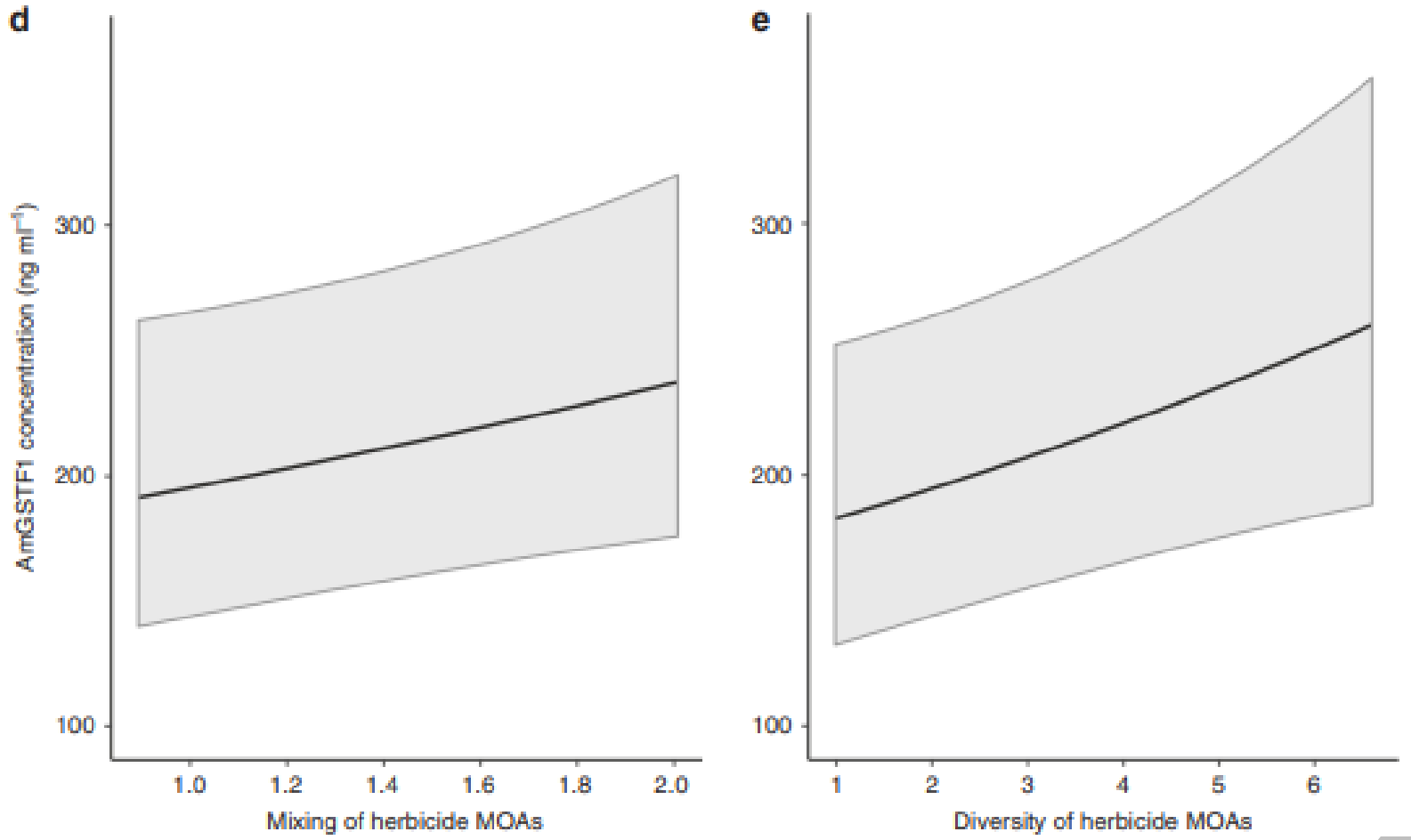
- A single resistance mechanism can cause resistance to multiple herbicide group
- Reduces effectiveness of mixing and rotating herbicides

BMP: Mix and rotate herbicides



Comont et al. 2020

Mixing herbicides does NOT slow metabolic resistance



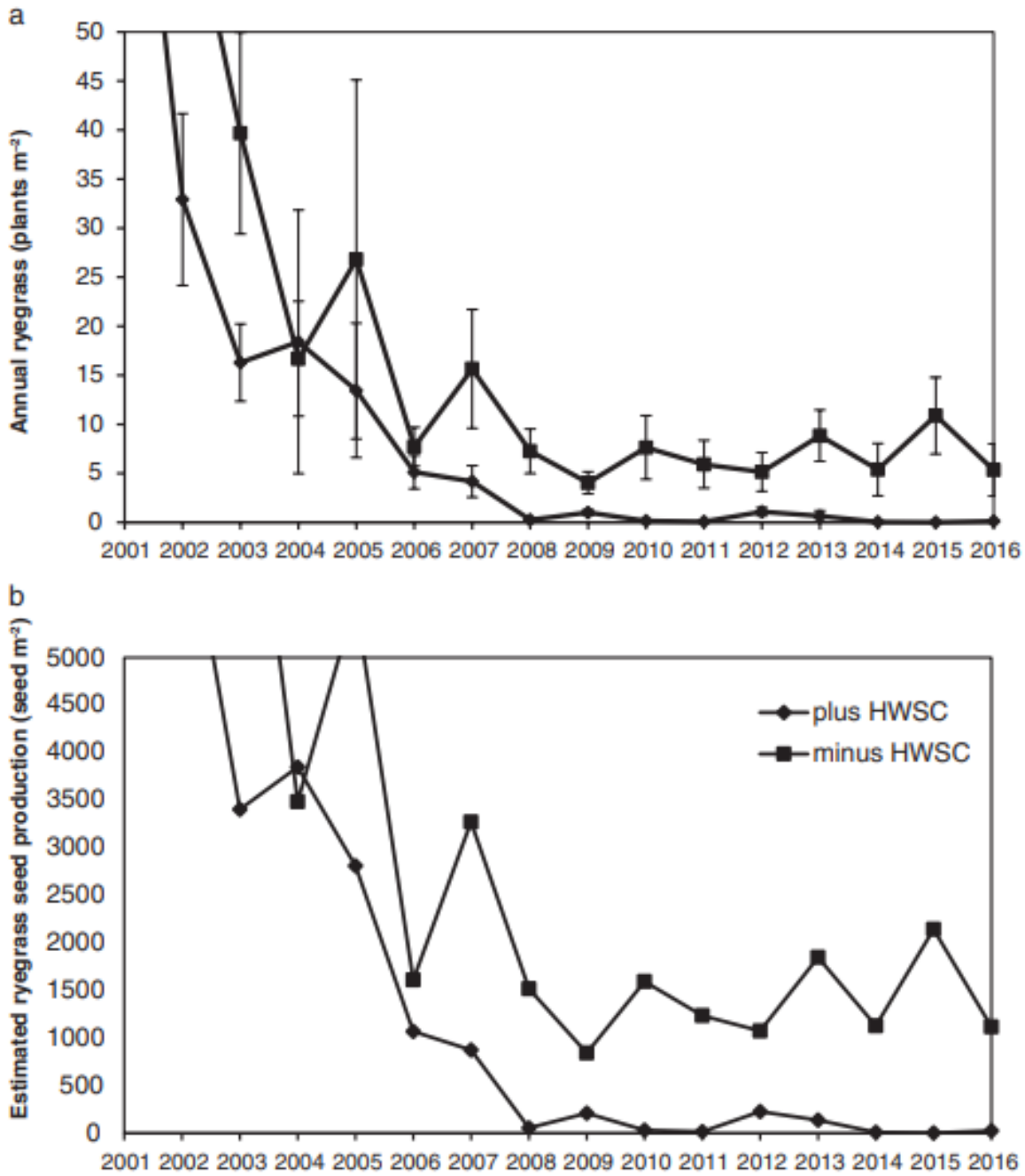
Comont et al. 2020

Response to metabolic resistance

- Minimize weed seed bank
- Adopt alternative management strategies

Harvest weed seed control

- Chaff lining
- Windrow burning
- Impact mills



Walsh et al. 2017

Harvest weed seed control can <u>complement</u> herbicides if used **<u>over time</u>**

Weed seed loss

~20 to 40% shatters at header (platform)

~ 50 to 80% to impact mill

Winans et al. 2021

Inter-row mowing

Row Shaver

Greenfield Robotics

https://www.agriculture.com/technology/chop-weeds-before-they-set-seed-to-help-deplete-the-seed-bank

Thermal weed control

Electrocution

47% control of Palmer amaranth

30% reduction in viable seeds

19% control of giant foxtail

Lasers

Directed energy

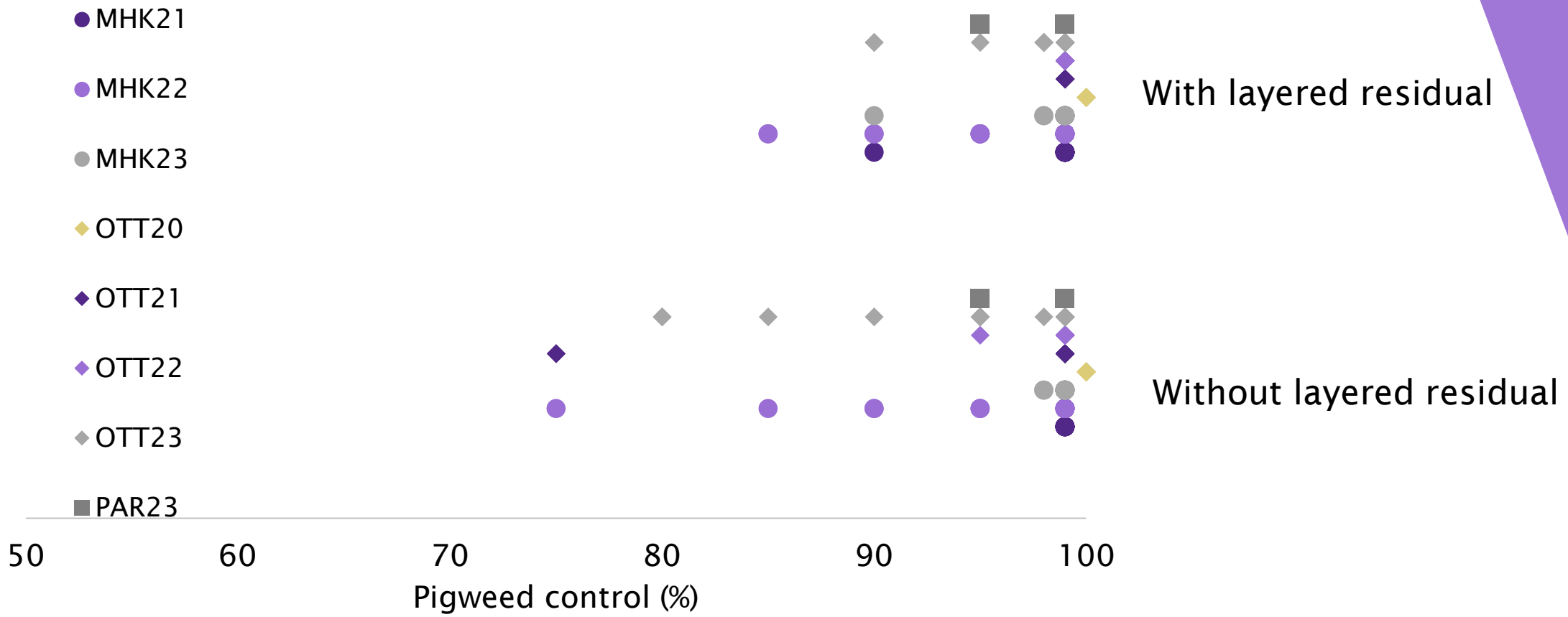
https://soybeanresearchinfo.com/research-highlight/electrocution-may-be-a-viable-method-to-control-weed-escapes/

Vaughn et al. 2022

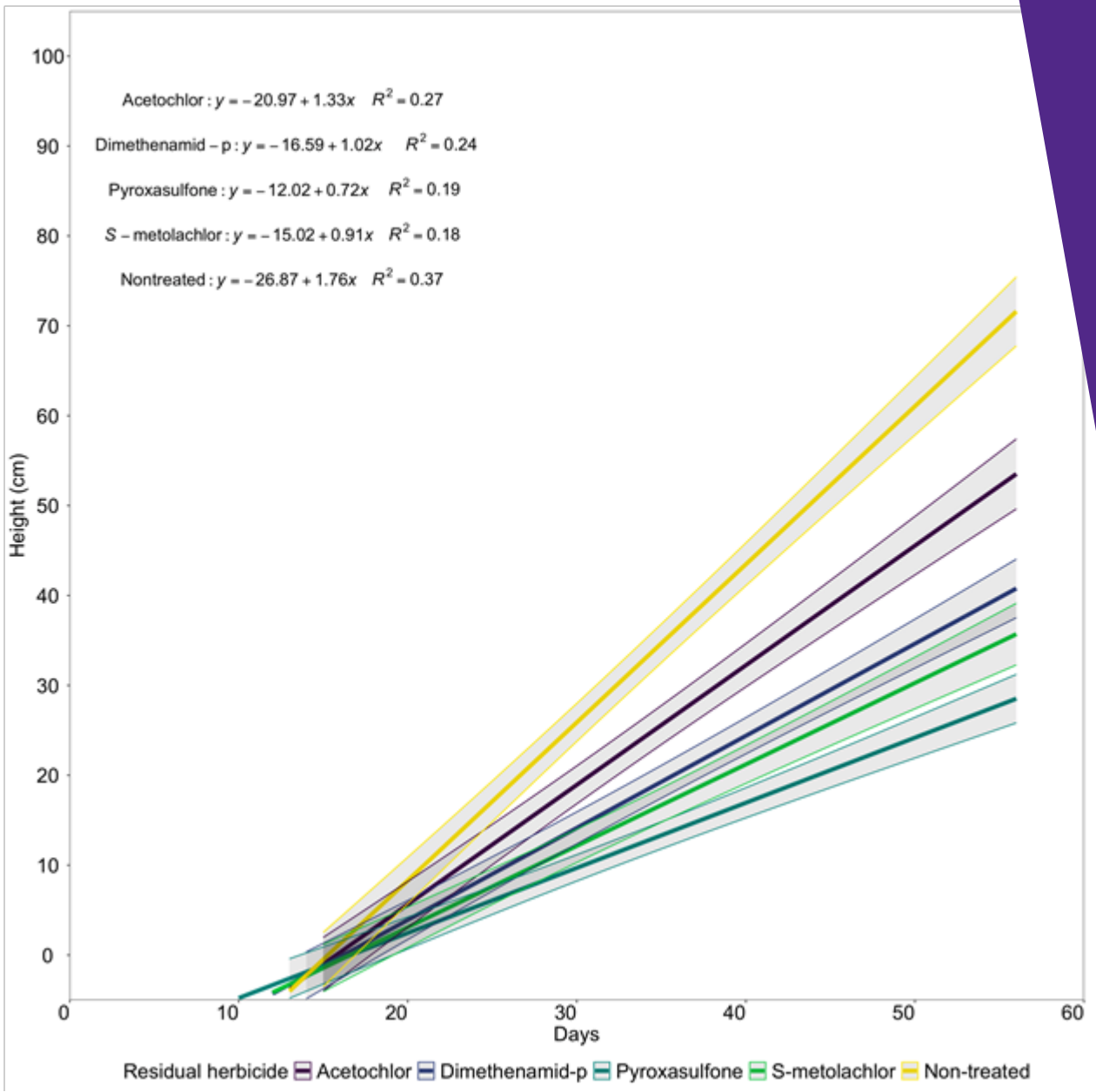
Optimizing herbicide applications

What about layered residuals?

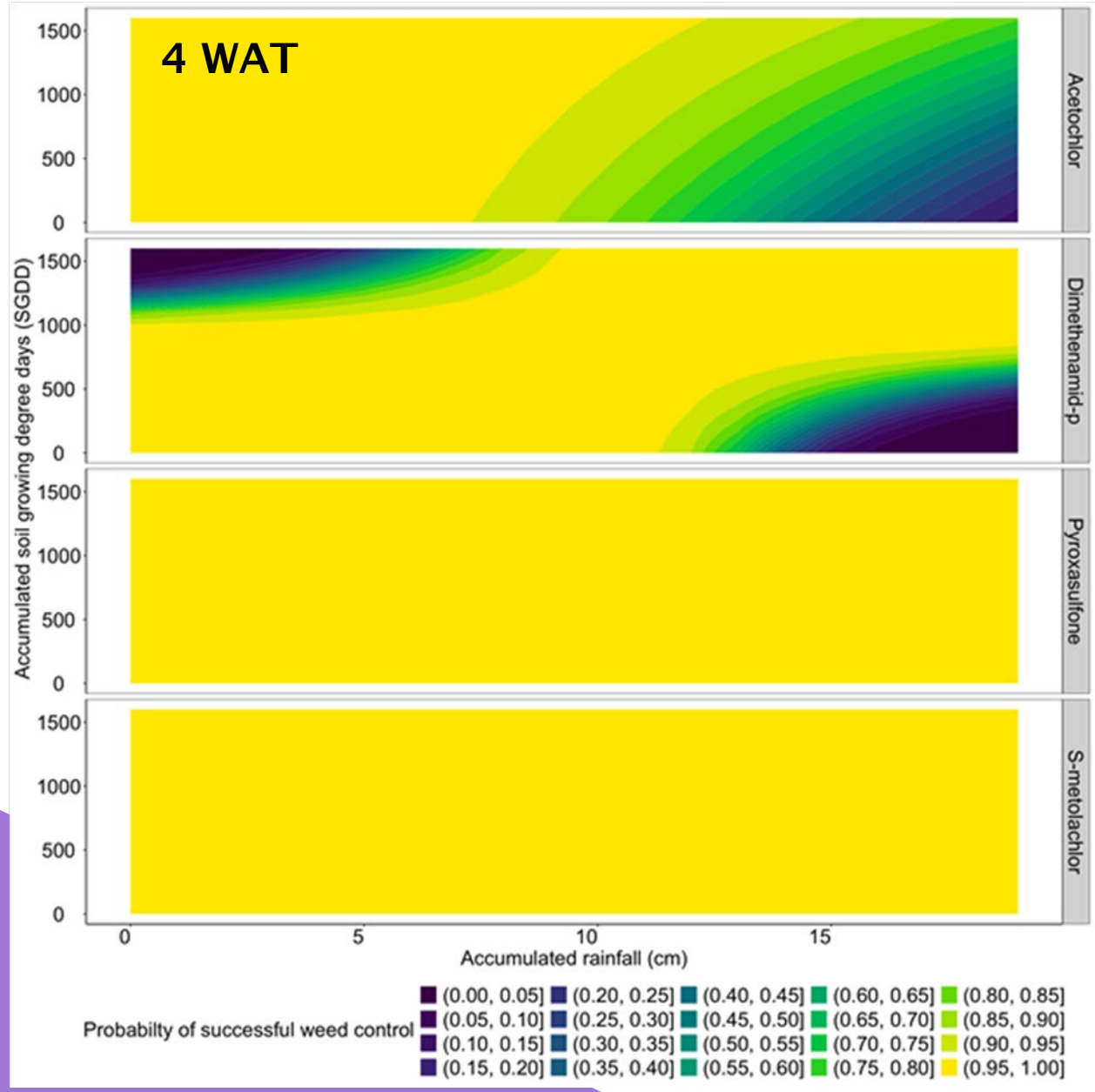
Pigweed control 8-12 weeks after POST treatment
Weed control and soybean yield satistically similar within location

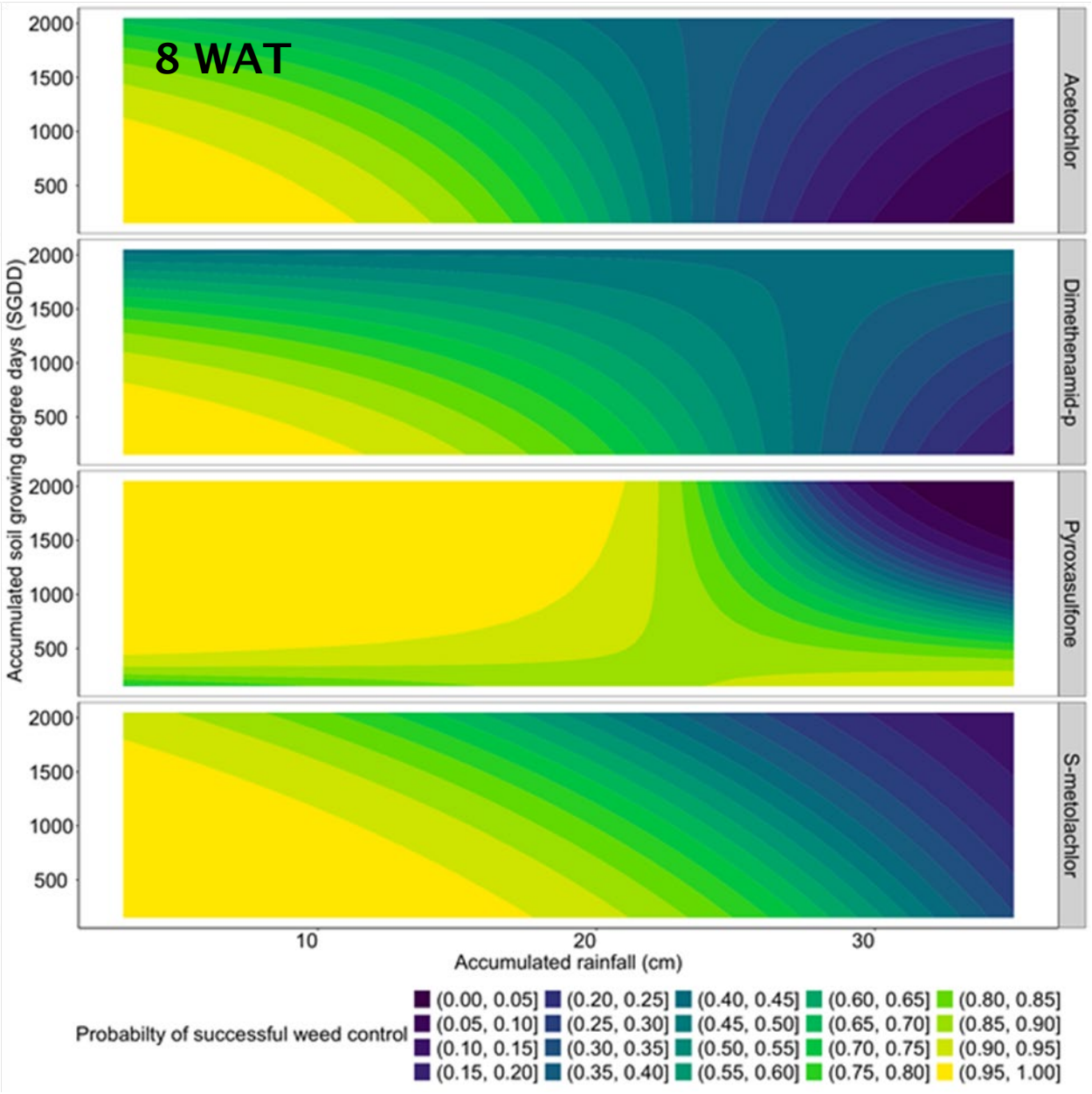


Palmer amaranth height as influenced by residual herbicide 2 to 8 weeks after application

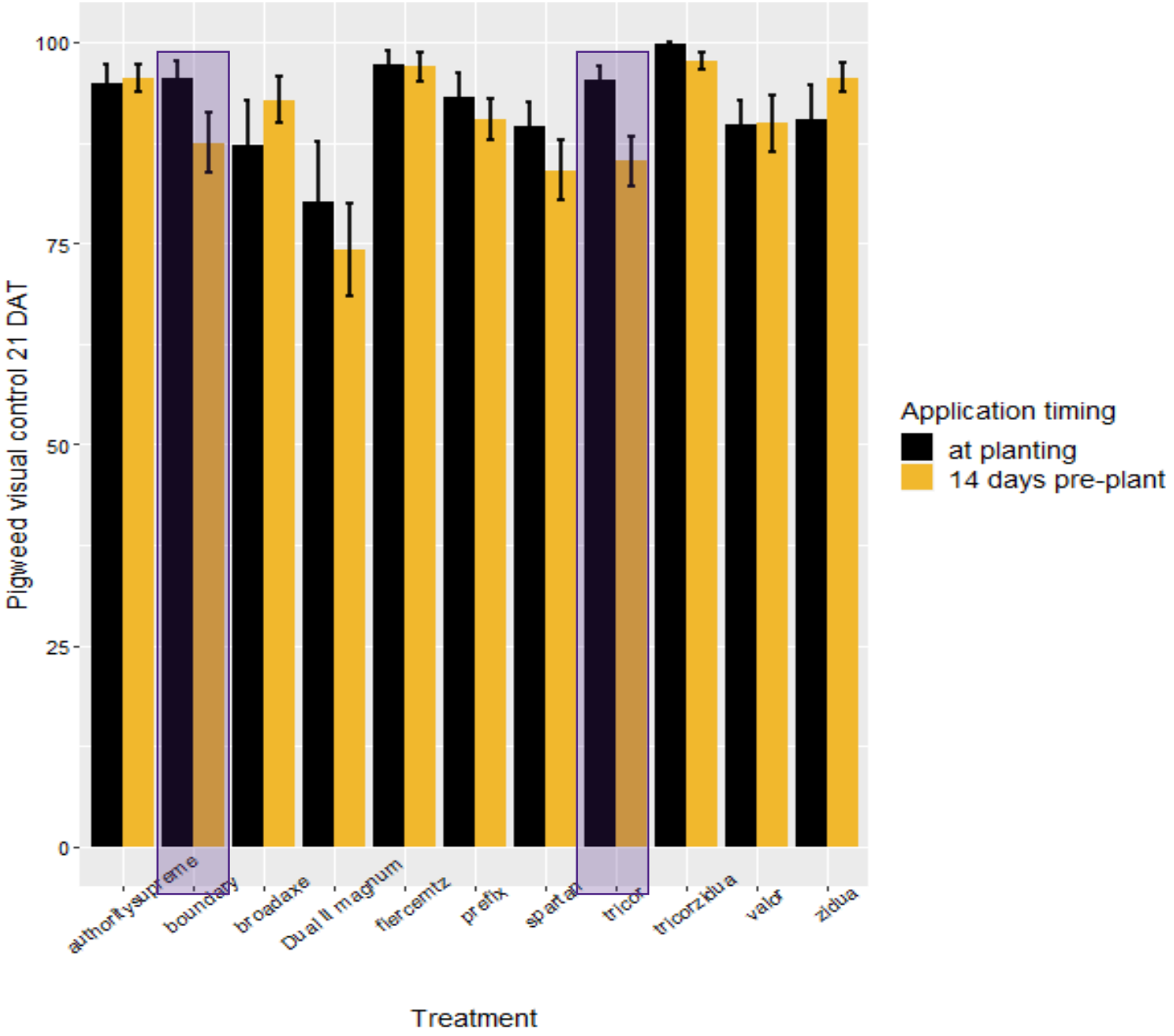


Probability of successful Palmer amaranth control



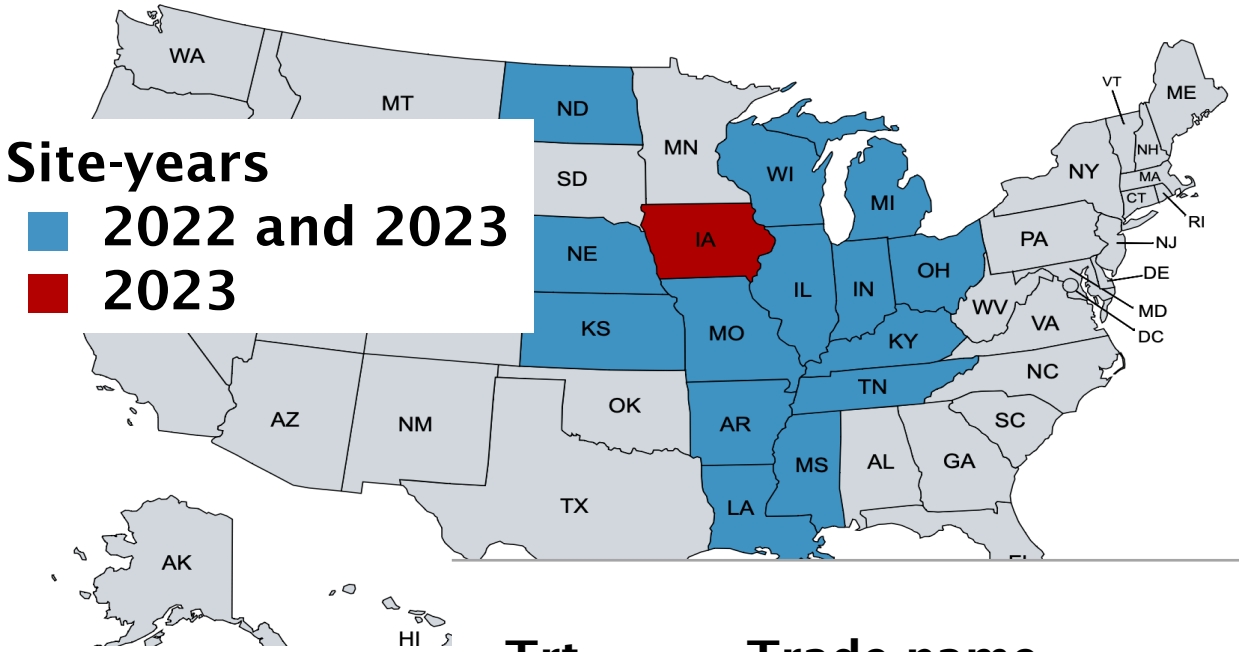


Meyeres 2024



- Pigweed control 21 DAP with residual herbicides applied 14 days before soybean planting or at planting
- Data averaged over 3 sites (Arkansas, Missouri, Wisconsin)

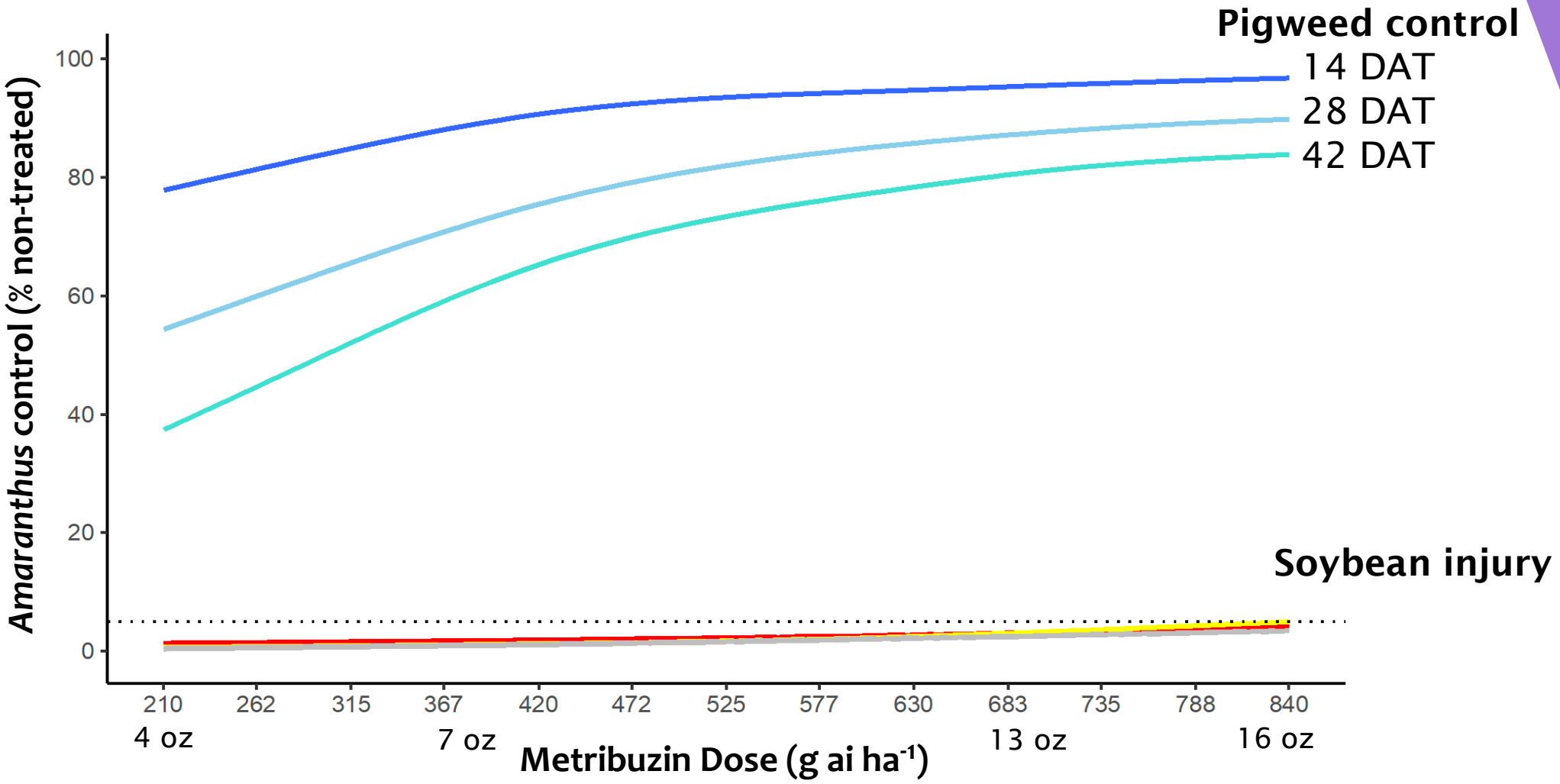
What is the best metribuzin rate?



Trt	Trade name	Active ingredient	Rate/A
1-13	Tricor DF or similar	metribuzin	4 to 16 oz (0.1875 to 0.75 lb)
14	Spartan®	sulfentrazone	10 fl oz
15	Dual II Magnum®	S-metolachlor	1.67 pt
16		Non-treated check	
17		Weed-free check	

Singh et al. 2024

Pigweed control and soybean response



Singh et al. 2024

How much metribuzin is required to achieve excellent control 42 DAT?

Low clay/OM; ideal precipitation			
Control	Fair (80%)	Good (90%)	Excellent (100%)
MTZ/A	13.8 oz 0.9 lb	15.9 oz 0.75 lb	*18 oz* *0.85 lb*

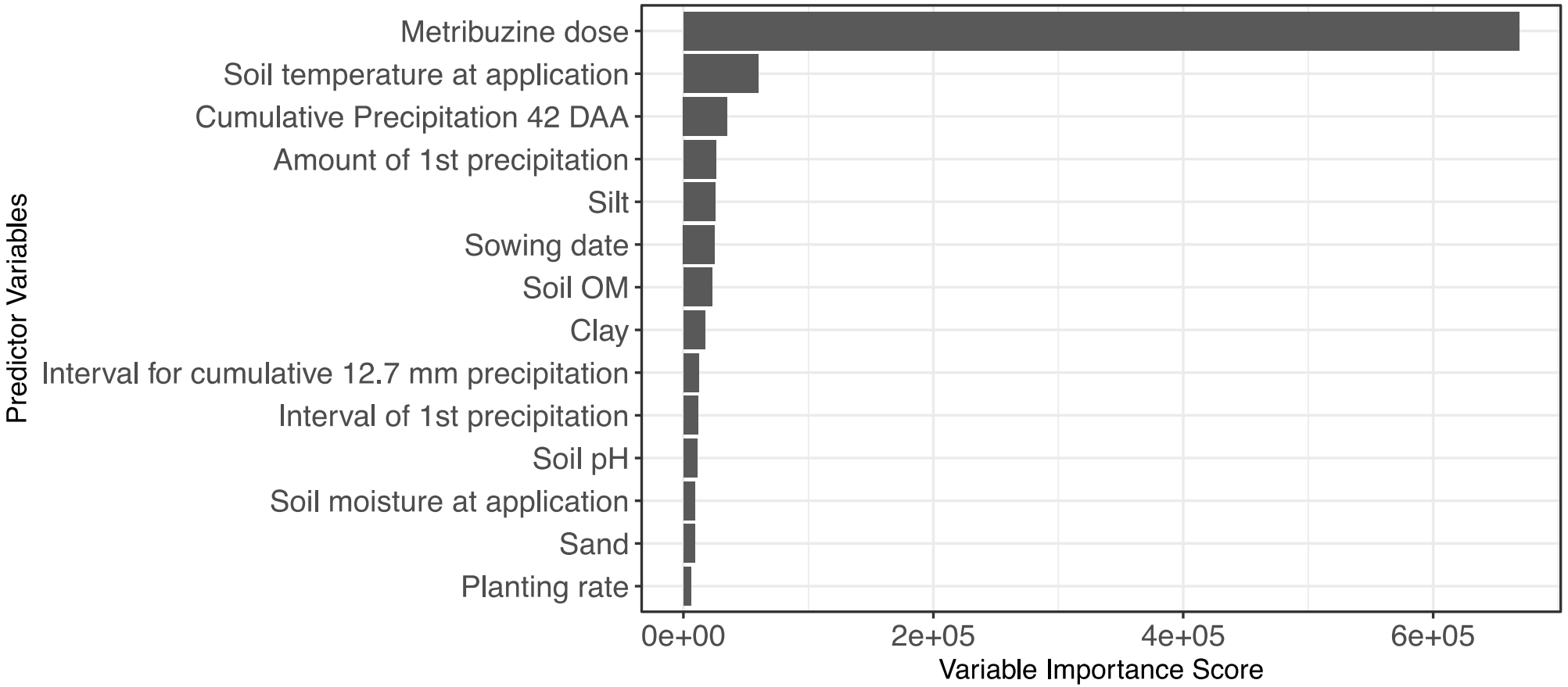
Low clay/OM; late precipitation			
Control	Fair (80%)	Good (90%)	Excellent (100%)
MTZ rate	14.7 oz 0.7 lb	*17.1 oz* *0.8 lb*	*19.5 oz* *0.9 lb*

Medium clay/OM; ideal precipitation			
Control	Fair (80%)	Good (90%)	Excellent (100%)
MTZ rate	14.3 0.67	15.8 0.74	*18.1* *0.85*

High clay/OM; ideal precipitation			
Control	Fair (80%)	Good (90%)	Excellent (100%)
MTZ rate	10.7 0.5	12.5 0.59	14.4 0.67

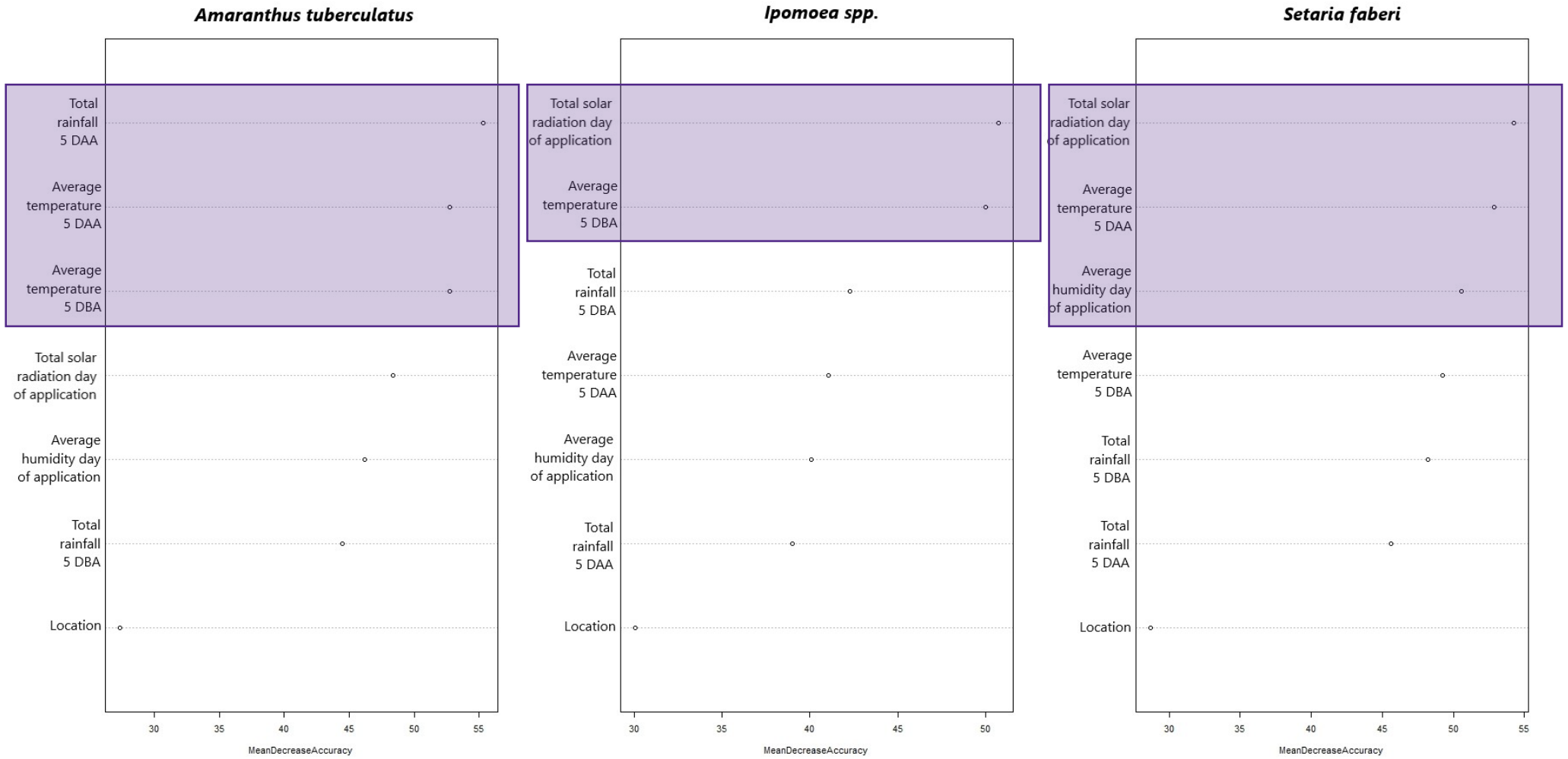
Singh et al. 2024

Variable importance to predict pigweed control 42 DAT

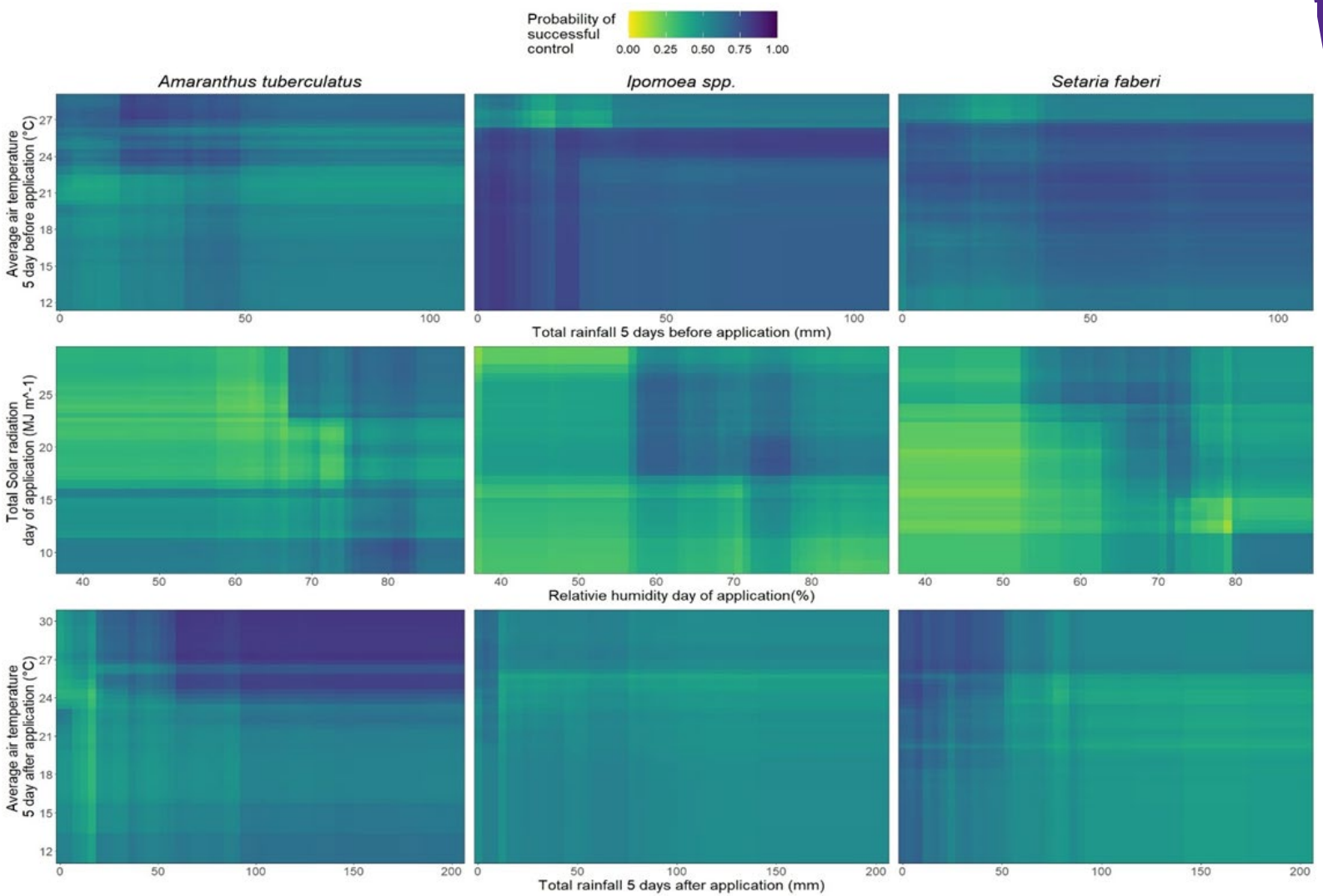


Singh et al. 2024

Variable importance to predict control of waterhemp, morningglory species, and giant foxtail with glufosinate 7 to 21 DAT



Landau et al. 2025



Landau et al. 2025

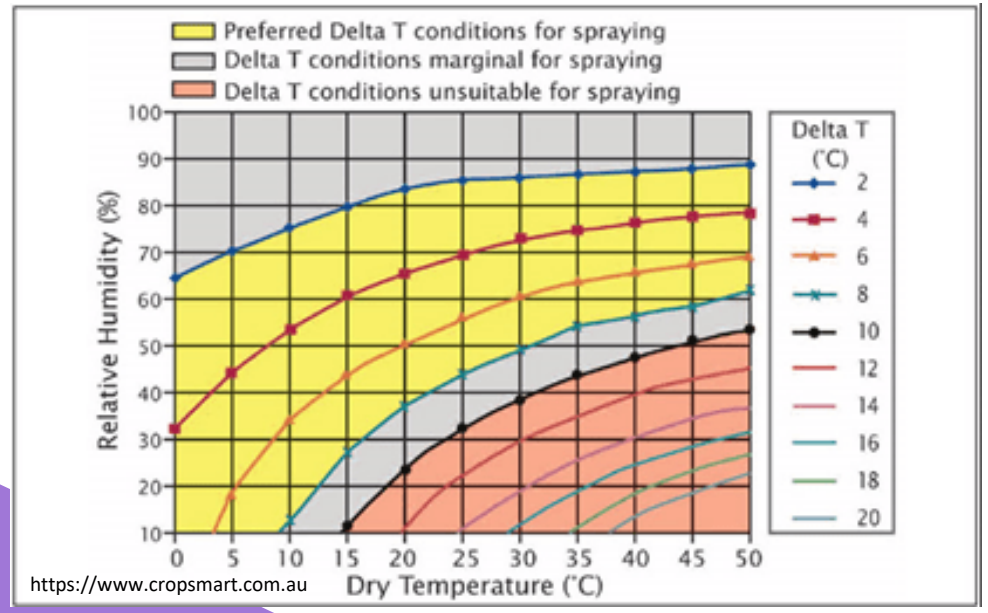
Effects of total precipitation and average air temperature 5 days before and 5 days after glufosinate application as well as solar radiation and relative humidity 1 day after application on the probability of successful weed control (≥85% weed control)

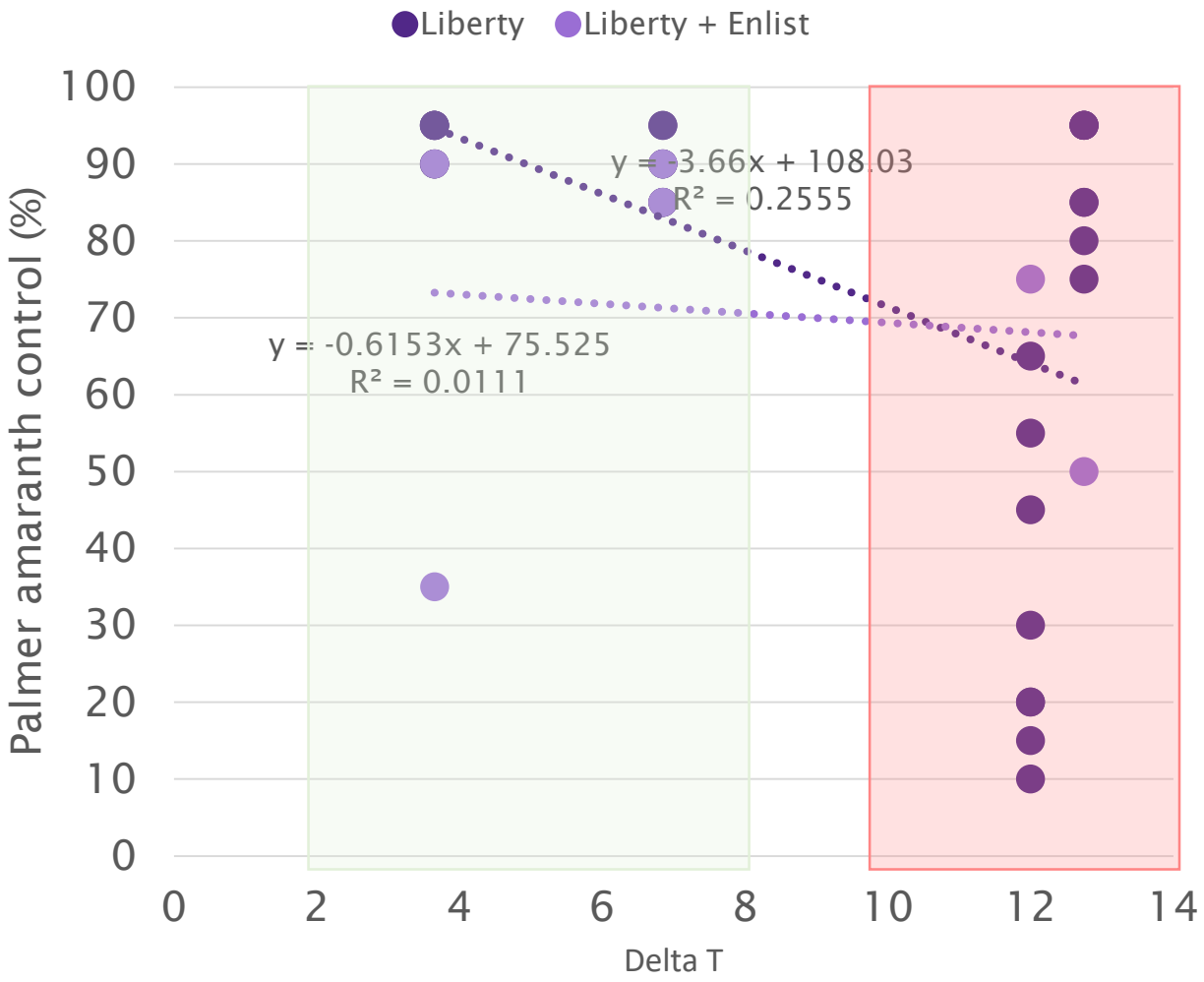
Enhancing Palmer Amaranth Control in Soybean: Effective Strategies for Glufosinate and 2,4-D Applications – Delta T

Indicator of droplet evaporation

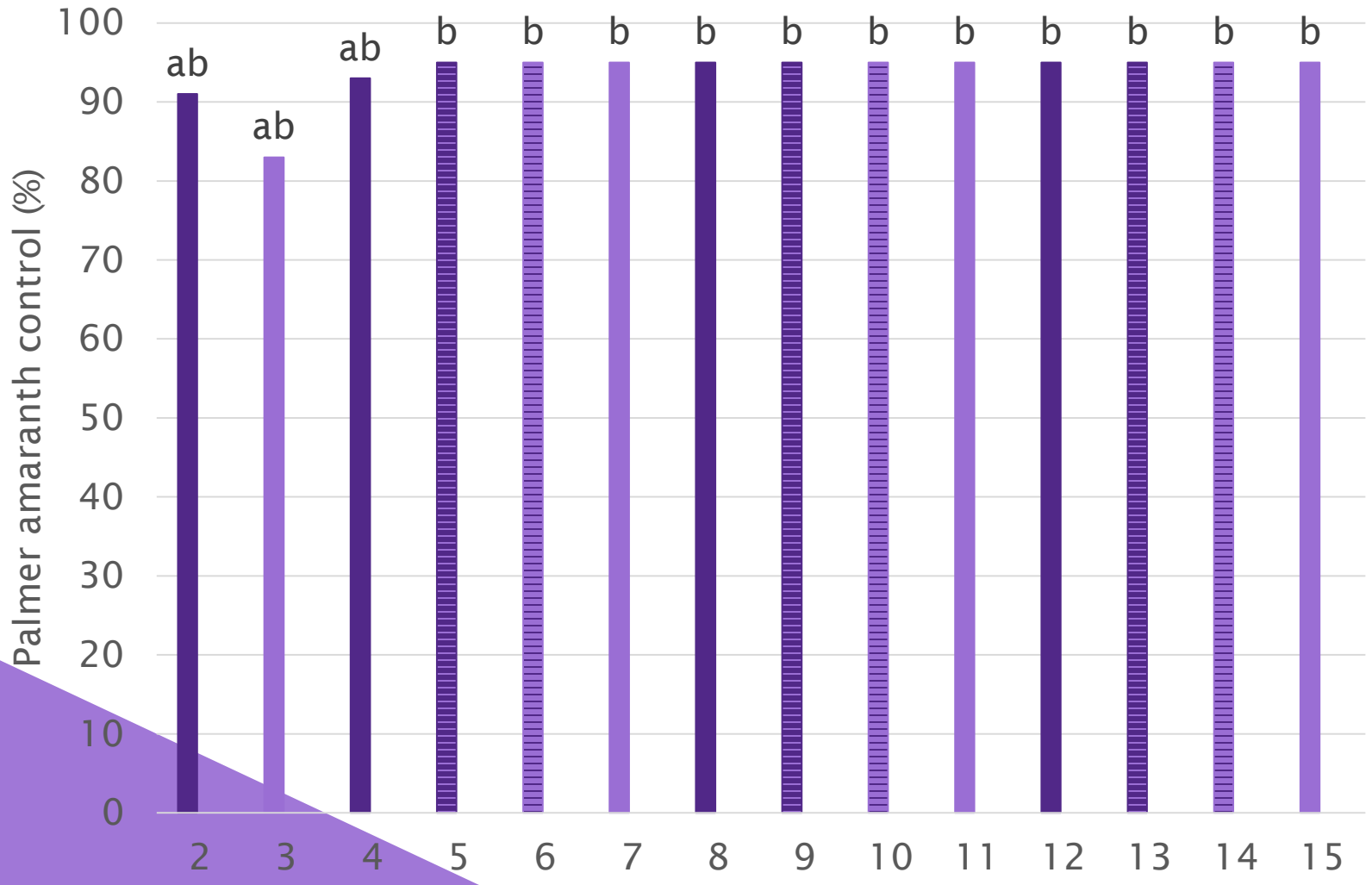
Function of temperature & humidity

Ideal is 2 to 8





Enhancing Palmer Amaranth Control in Soybean: Effective Strategies for Glufosinate and 2,4-D Applications



Treatments			
	Herb. 1	Herb. 2	Interval
2	Liberty		
3	Liberty + Enlist		
4	Liberty	Liberty	3 DAA
5		Liberty + Enlist	
6	Liberty + Enlist	Liberty	
7		Liberty + Enlist	
8	Liberty	Liberty	10 DAA
9		Liberty + Enlist	
10	Liberty + Enlist	Liberty	
11		Liberty + Enlist	
12	Liberty	Liberty	14 DAA
13		Liberty + Enlist	
14	Liberty + Enlist	Liberty	
15		Liberty + Enlist	

Mohan et al. 2024

TARGETED SPRAYING

Technically, not “spot spraying”

Directed spray application, typically labor intensive

Also not a “prescription” application

Based on map derived from pre-existing information

Targeted Spraying Systems

FACTORS INFLUENCING FARMER ADOPTION OF TARGETED SPRAYERS

Collaborators: Haag, Falk Jones, Hock

STUDY METHODS

Qualitative study based on theory of planned behavior and technology acceptance model[1]

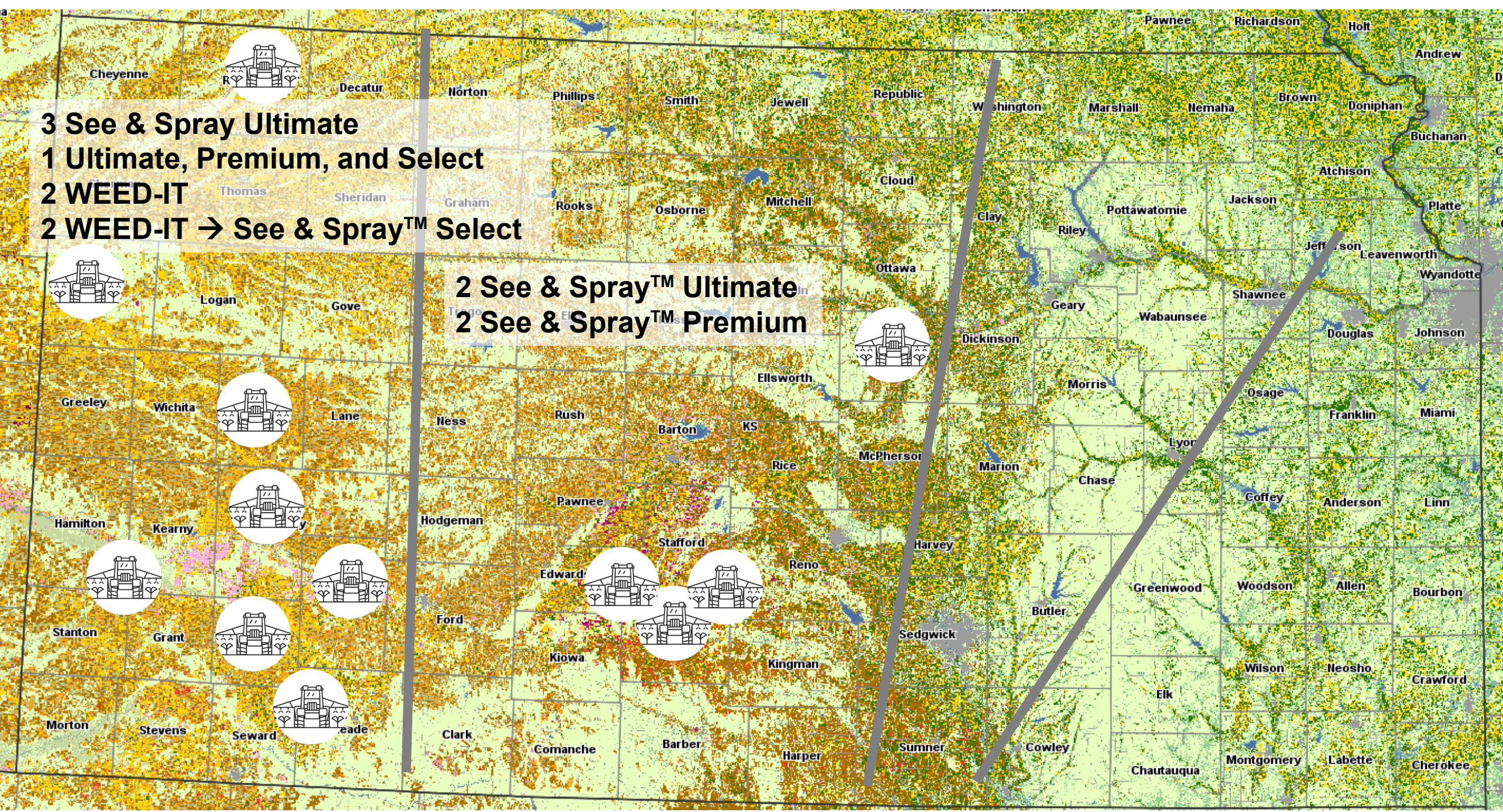
Initially identified 7 farmers

- Added 10 potential participants based on conversations

Interviewed 11 farmers between May and August

- 9 were the primary person making the decision to purchase the sprayer
- 2 initiated the purchase of the sprayer

[1]Mohr and Kuhl 2021



https://nassgeodata.gmu.edu/CropScape/

Farmer Demographics

- Age: 26 to 51 years
  - Average: 44 years
- Acres sprayed total: 7,000 to 350,000
  - Average: 72,000
- Acres sprayed with site-specific technology: 20 to 70%
  - Average: 44%
- 7 of 11 participants also own a ‘broadcast only’ sprayer
- 6 of 11 use a QuickDraw system for tendering, others use similar
  - 2 See & Spray™ Ultimate owners purchased QuickDraw with the sprayer

What are the greatest benefits of a targeted sprayer?

See & Spray™ Ultimate owner

*The **money savings** initially is what it'll be long term, I think it's reducing that weed bank and reducing weed pressure and reducing herbicide expense, not just because you're doing see and spray, but because you have less weed pressure.*

See & Spray™ Premium owner

*I think number one is the **environmental impact***

*I think guys are going to be **more apt to go out and spray stuff earlier**.*

See & Spray™ Select owner

*Overall **efficiencies of your time***

What are the greatest limitations of a targeted sprayer?

See & Spray™ Ultimate & Premium owners

*Well, **coverage** was one we've talked about that a little bit. It's not bad, it's just it's not as good as being able to shoot it from both sides.*

***Speed** for some guys is probably a limitation*

***Sometimes the only time we can spray is at night**, so that's probably one of the biggest limitations.*

***Dust and shading** a little bit certain times of the day, if the sun's over here on this side, this sides run kind of in the dark, in the shade, and then it gets a little dust, and it makes those cameras not want to read.*

***Cost is the biggest barrier**, or because you gotta buy [the subscription fee].*

*It's like **going over a terrace**. When it comes up [over the required height], it sprays that. And so you're going to spray more [of a terraced field]*

See & Spray™ Select and WEED-IT owners

*I think **we have to cover it at least twice more in a year** than we do [with broadcast sprays]*

Other considerations

More complicated tendering in dual-tank systems

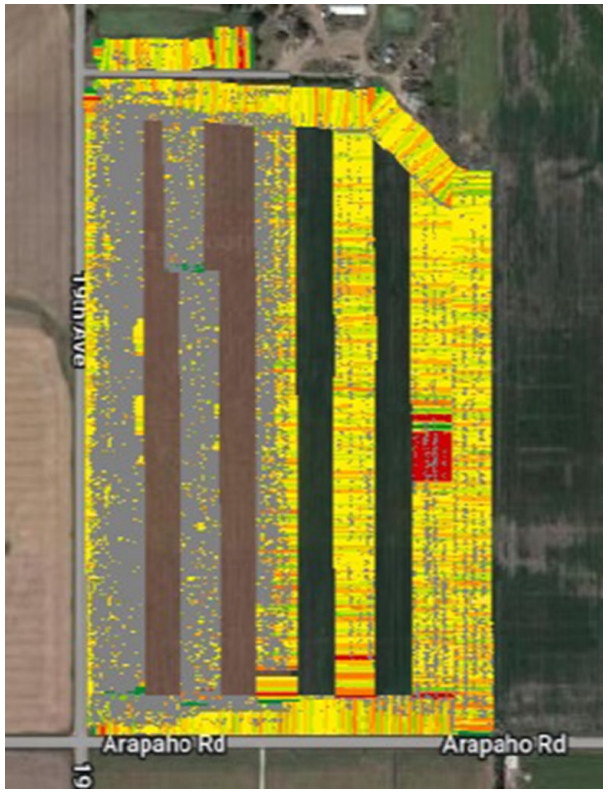
What portion of acres are suited for targeted application??

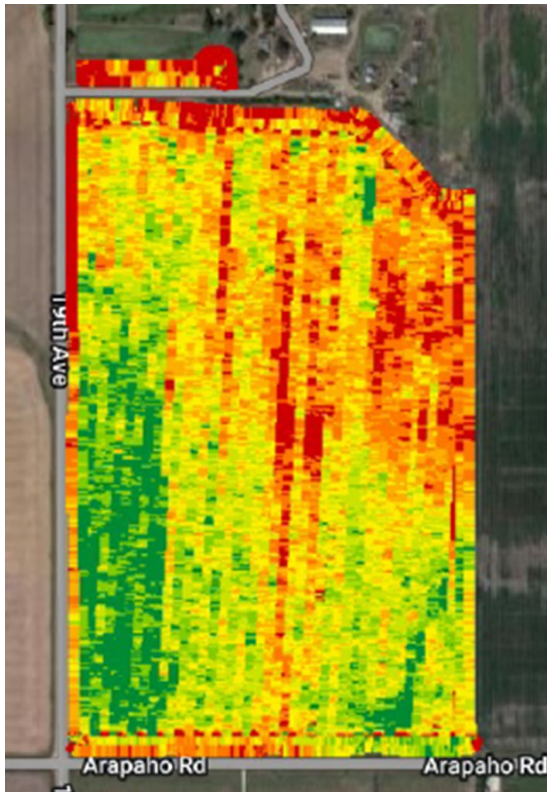
Regulatory questions

- What rate is legal?
- Can you get around tank-mix restrictions?
- Mitigation points

On-Farm demonstration

See & Spray treated 55% of area covered

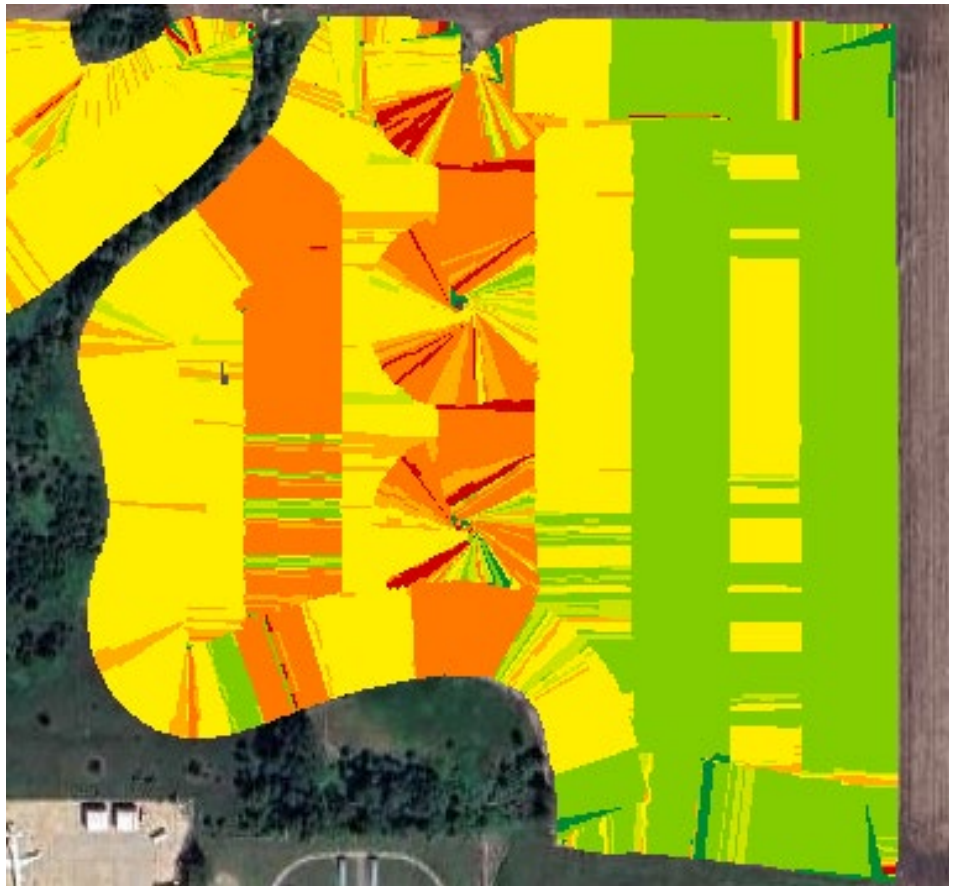




Used 350 gallons less spray solution

- Reduced herbicide use by
- 5.9 gallons Liberty
- 1.1 gallons NIS
- 70 lbs AMS

Variable-rate residual herbicide application based on weed distribution and soil texture



Based residual herbicide applications on:

- Soil properties (little variation)
- Previous as-applied map

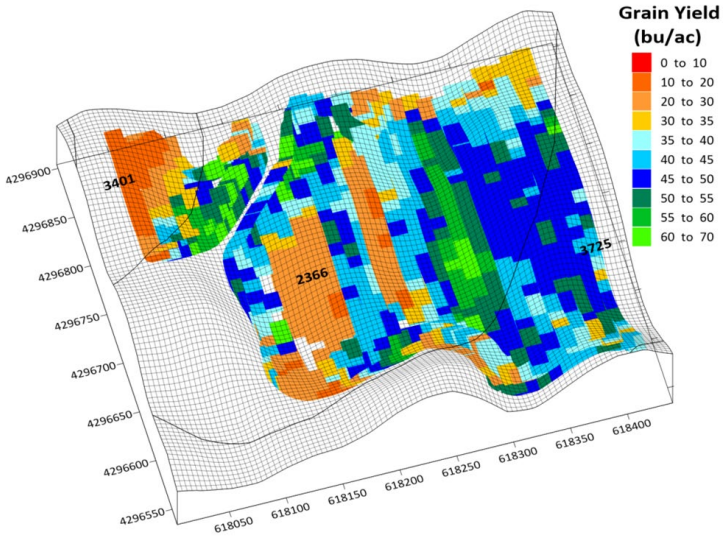
Three rates for each herbicide:

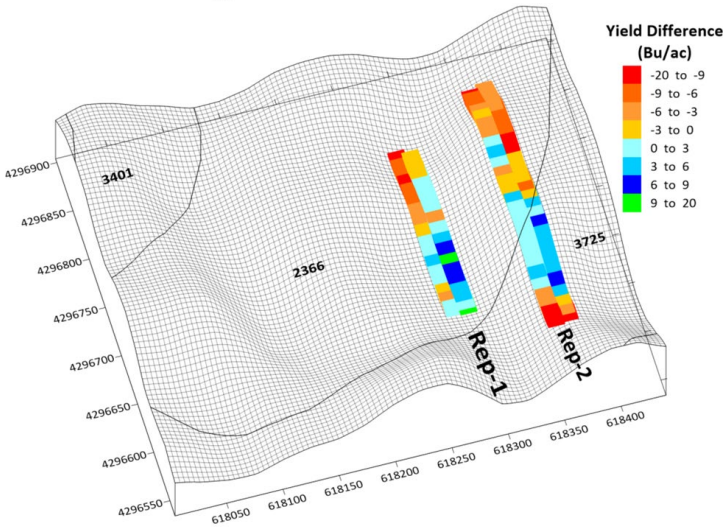
- high (green)
- medium (orange)
- low (yellow)

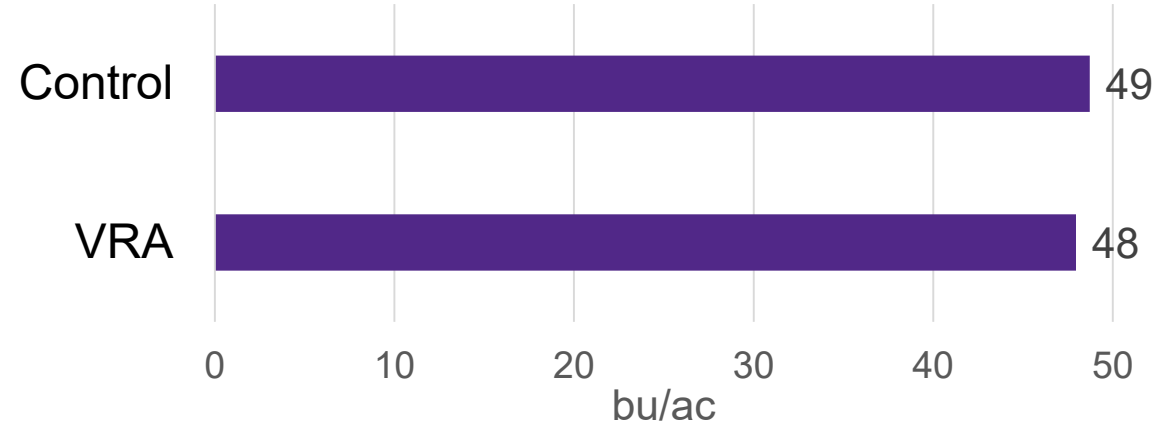
Caldieraro et al. 2024

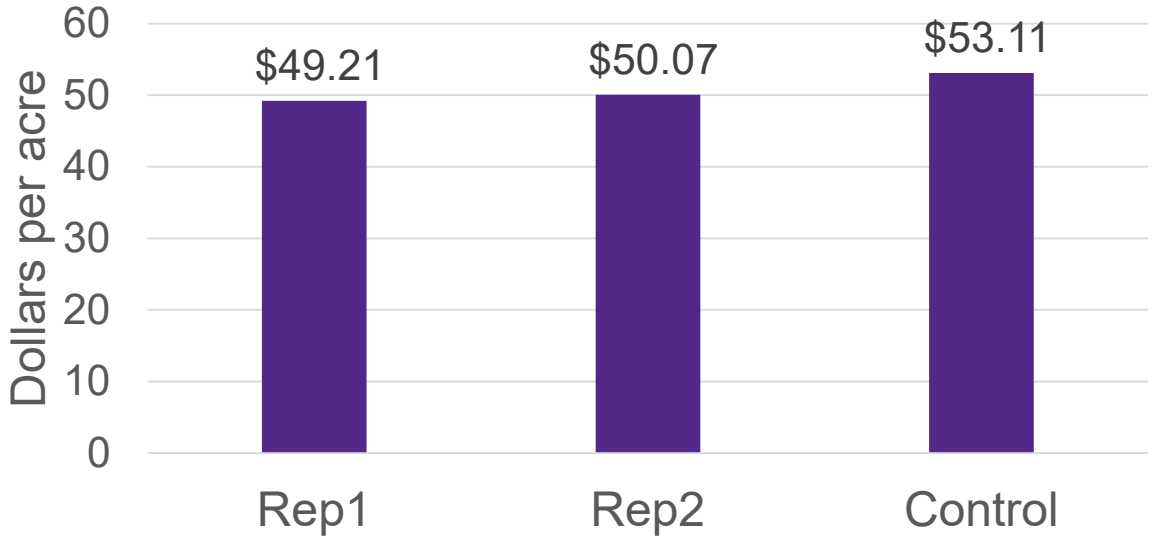
Variable-rate residual herbicide application based on weed distribution and soil texture

Leno Caldieraro, Sarah Lancaster, Deepak Joshi









Take away

- Zero tolerance for seed production and non-chemical tactics needed to address metabolic resistance
- Consider environment when planning applications
- Acres suitable for targeted application is a key factor when considering adopting the technology

Herbicide resistance updates:S8E10, S5E2, S3E13, S1E4

Metabolic herbicide resistance: S5E14

Harvest weed seed control: S6E4, S2E1

Thermal weeding: S8E8, S4E13

Residual herbicides: S8E11, S6E11, S4E4

Targeted herbicide applications: S6E8, S2E12

Let's Connect!

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War Against Weeds podcast

eUpdate.agronomy.ksu.edu

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