

# Getting Rid of Weeds using Multiple Control Tactics

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North Dakota State University and  
University of Minnesota and  
Minn-Dak Farmers Cooperative

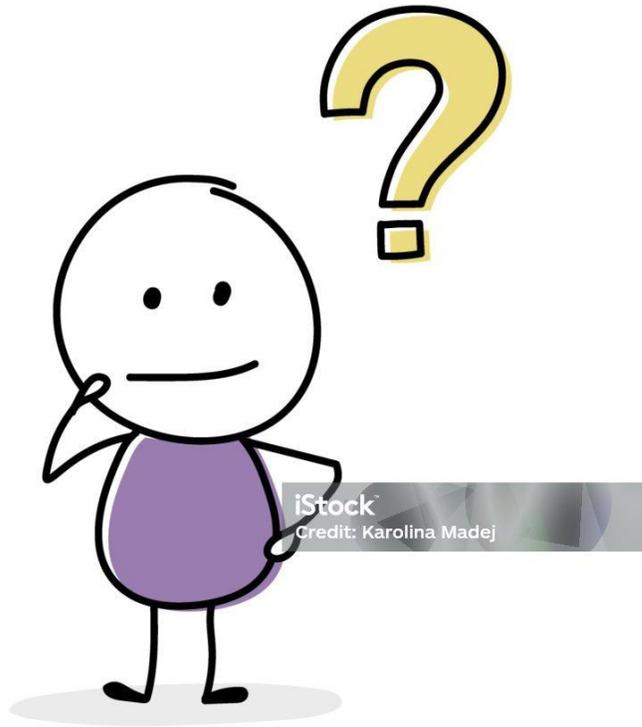


# Thank you to our collaborators

- Sugarbeet Research and Education Board: Carson Klosterman and Matt Hasbargen
- Minn-Dak Farmers Coop research team, Emma Burt, Brad Schmidt, Gibson Hasbargen, and Aidan Bohn
- Our grower cooperators:
  - Pat Freese

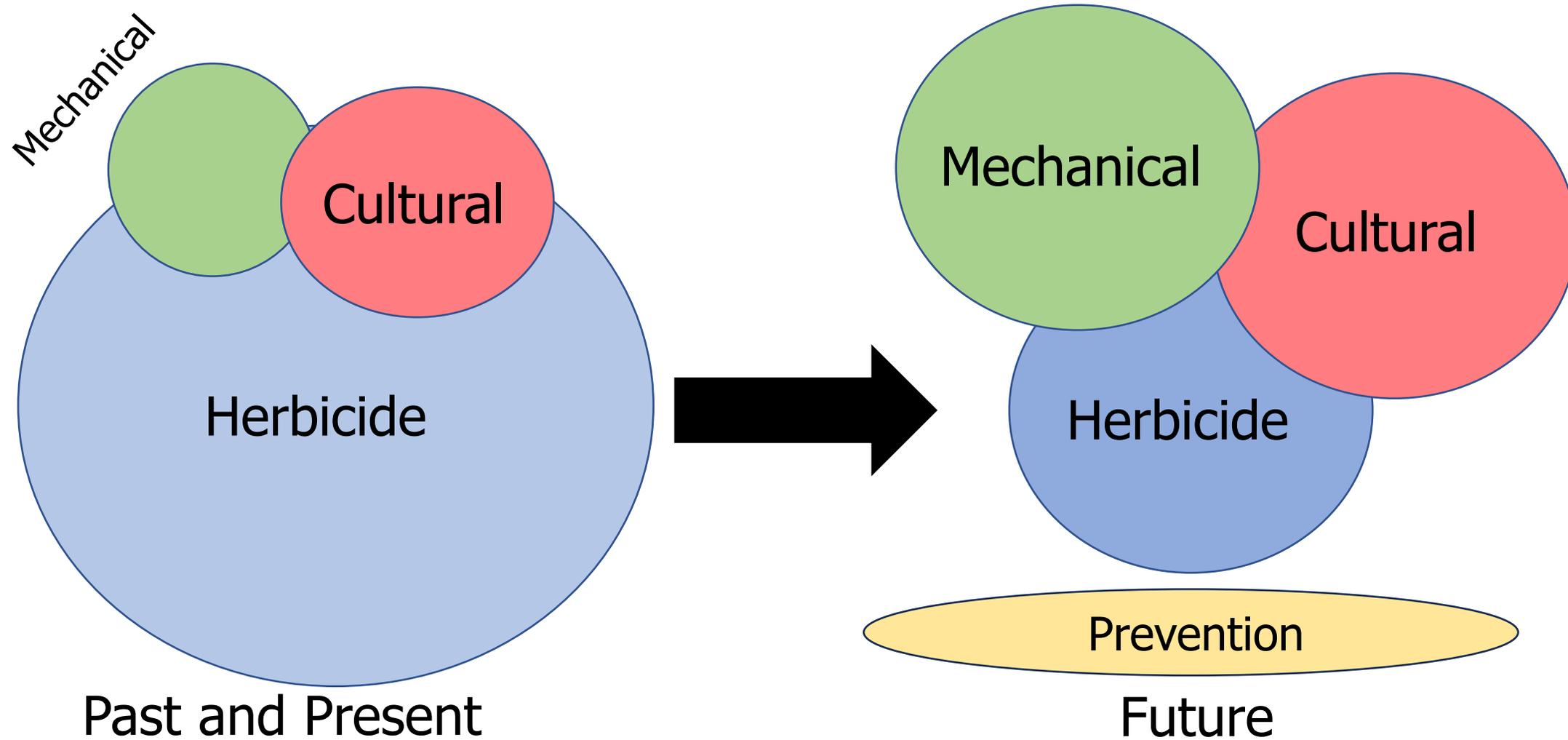


# How are we going to control weeds in the short term?

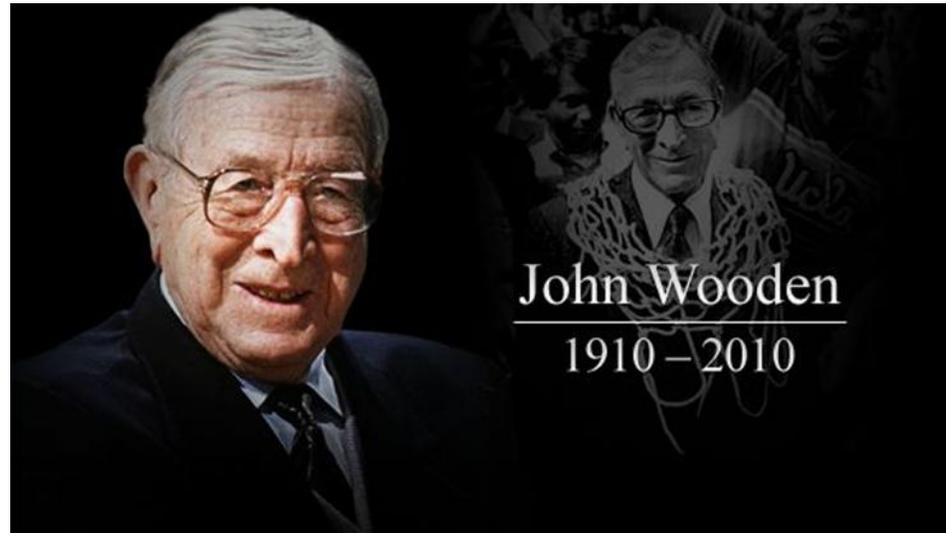


- Focus groups at Renville, Wahpeton and Moorhead in November and December 2025
- Growers, ag-retailers, crop consultants and cooperative agriculturalists
- 2 hour brainstorming session with action items for followup

# Integrated Weed Management



**"It's the details. Little things make big things happen"**



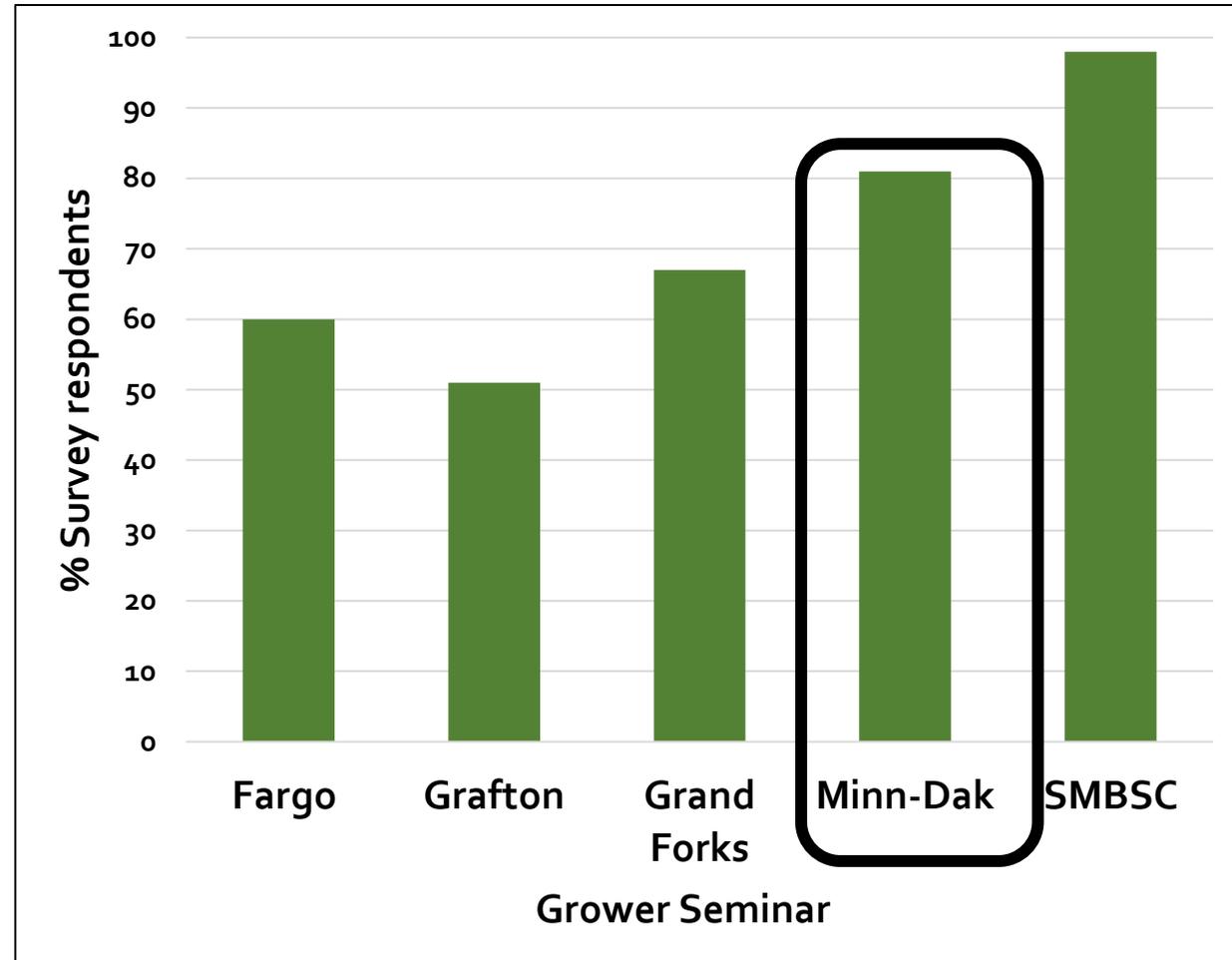
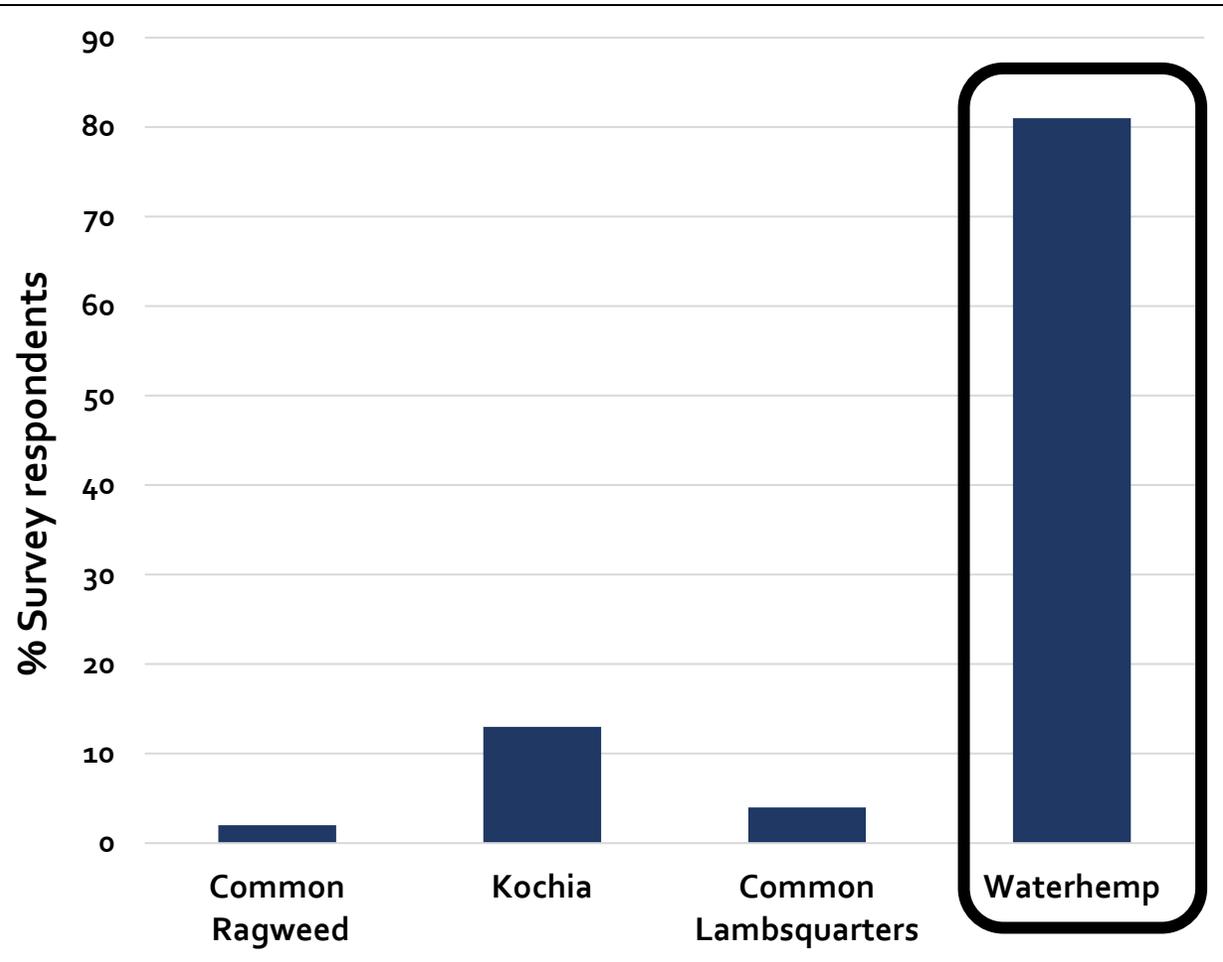
**It's the weed management details. Little things potentially make weed-free crop fields a possibility**

# Outline:

## Use the winter season to get back into the classroom

- Study waterhemp biology
- Waterhemp control in sugarbeet; across the crop sequence
- Spray nozzles
- Electricity
- Herbicide resistance

# What was your worst weed control challenge in 2024? How do you compare to other regions<sup>a</sup>?



<sup>a</sup>Turning Point Survey, 2025 Sugarbeet Growers Seminars



# Rainfall (inch) measured at Rosemont MN, 2022 and 2023

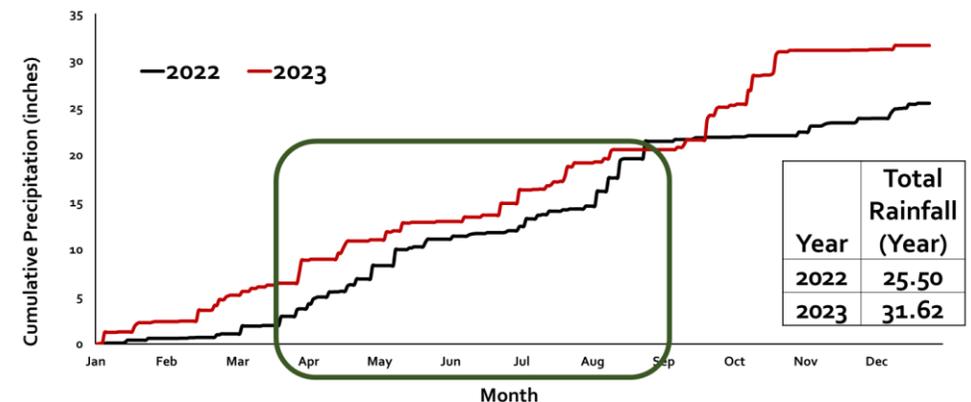


- Waterhemp emergence in a soybean field in Rosemont, MN (*Yu et al.*)

Year	First observed seedling	50% emergence	90% emergence	Total Waterhemp <sup>a</sup>
2022	24-May	27-May	5-July	130
2023	15-May	28-June	27-July	227

<sup>a</sup>Cummulative waterhemp emergence in 1 square meter

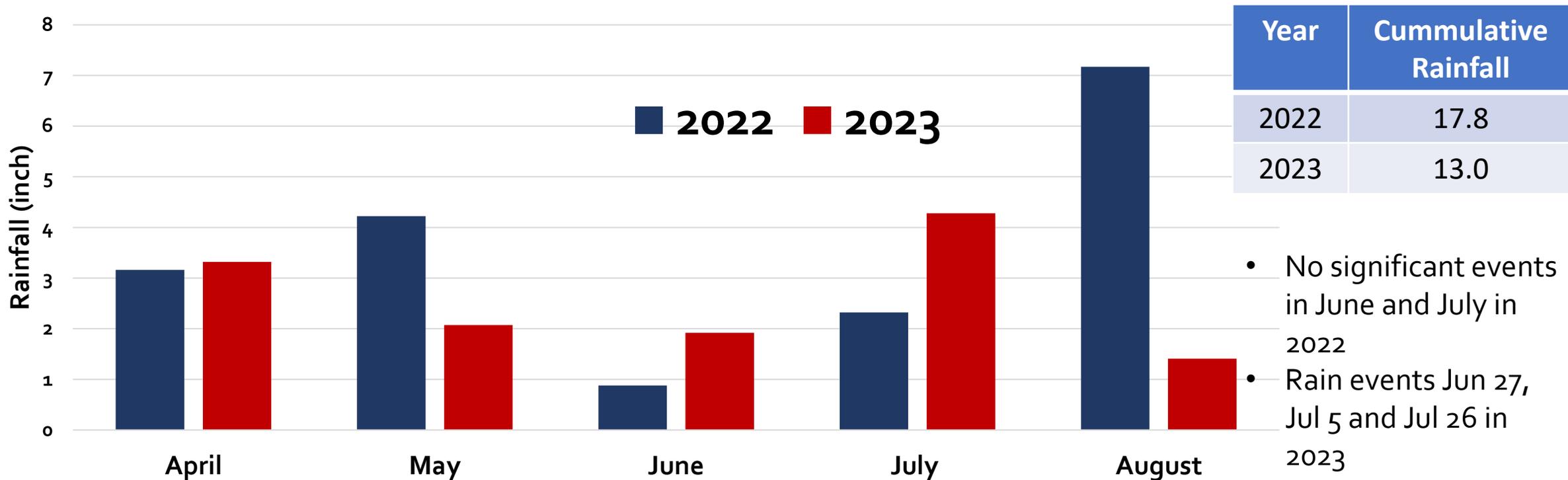
Rainfall (inch) measured at Rosemont MN, 2022 and 2023



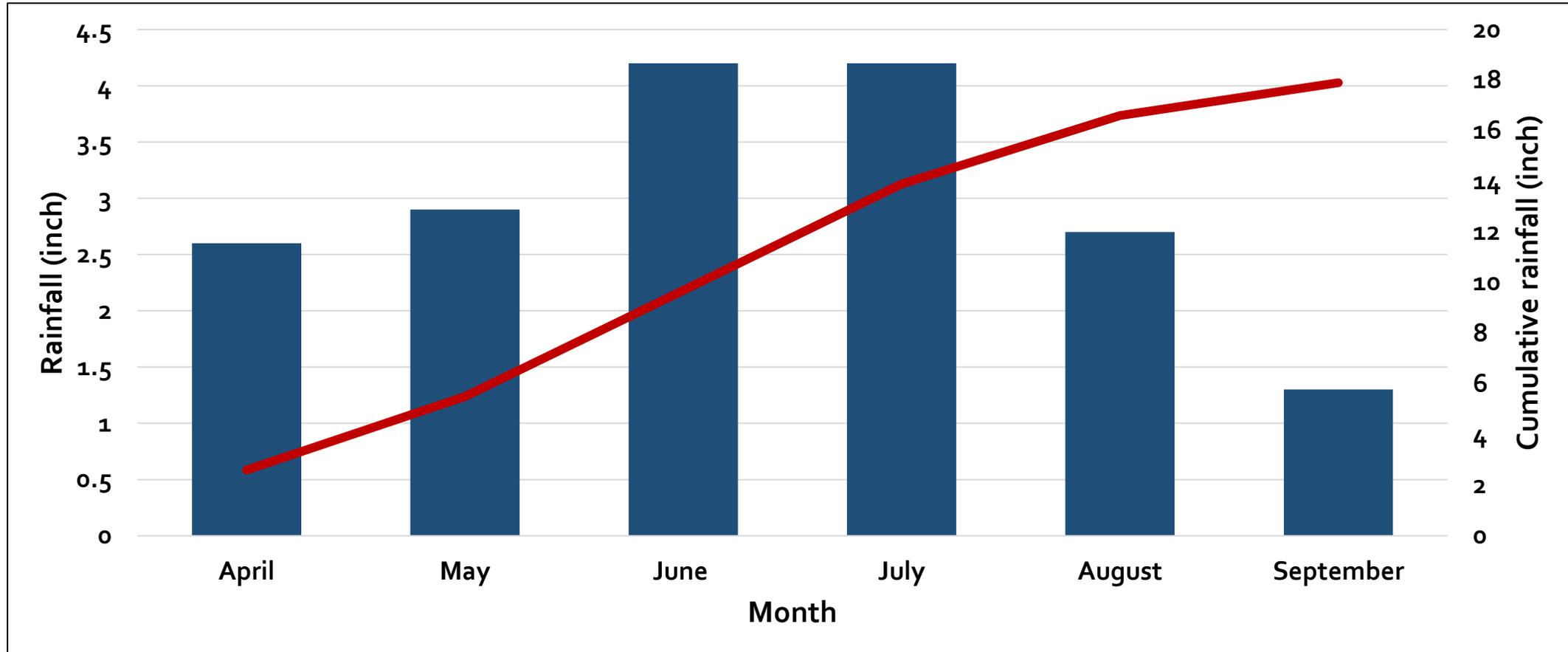
# Rainfall pattern may explain the differences in emergence pattern

Year	First observed seedling	50% emergence	90% emergence	Total Waterhemp <sup>a</sup>
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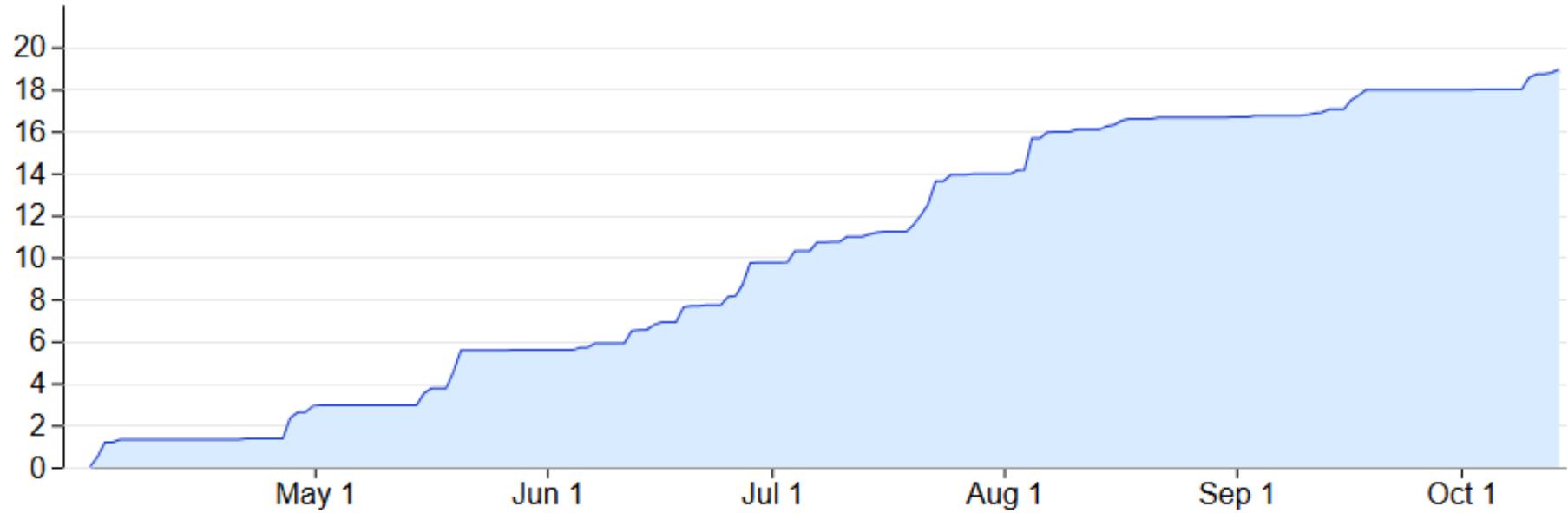
<sup>a</sup>Cummulative waterhemp emergence in 1 square meter



# Rainfall April through September, 2025, Pat Freese Farm, Brushvale, MN

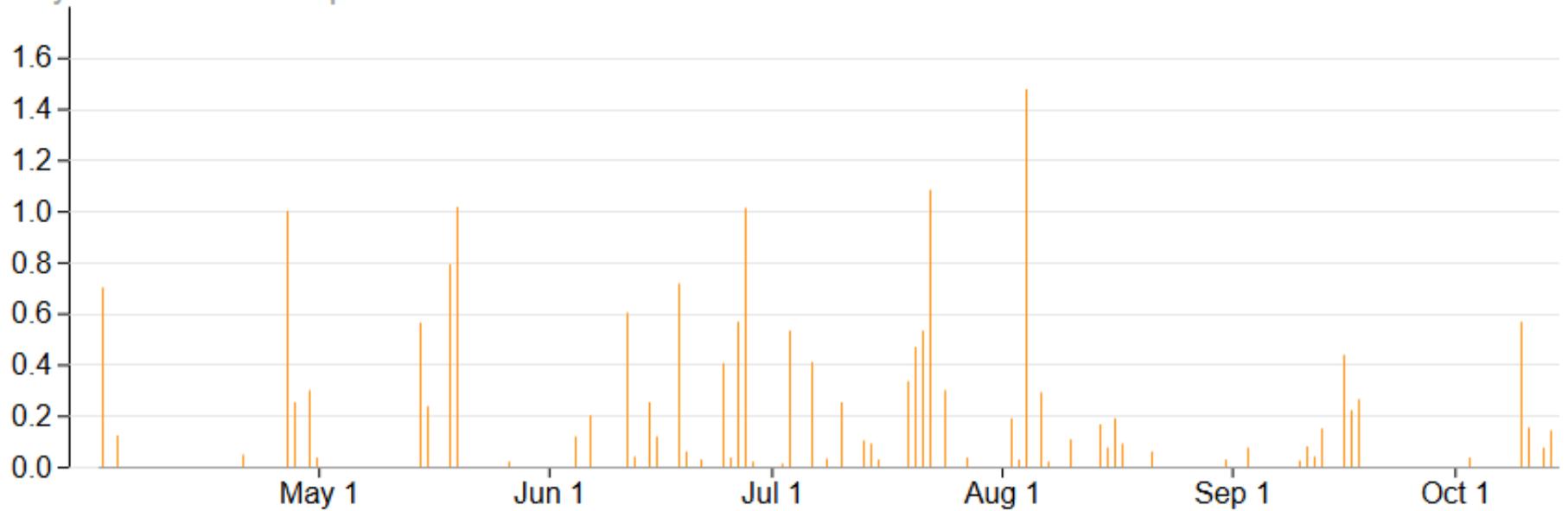


Accumulated Precipitation



**Pat Freese Farm,  
Brushvale, MN**

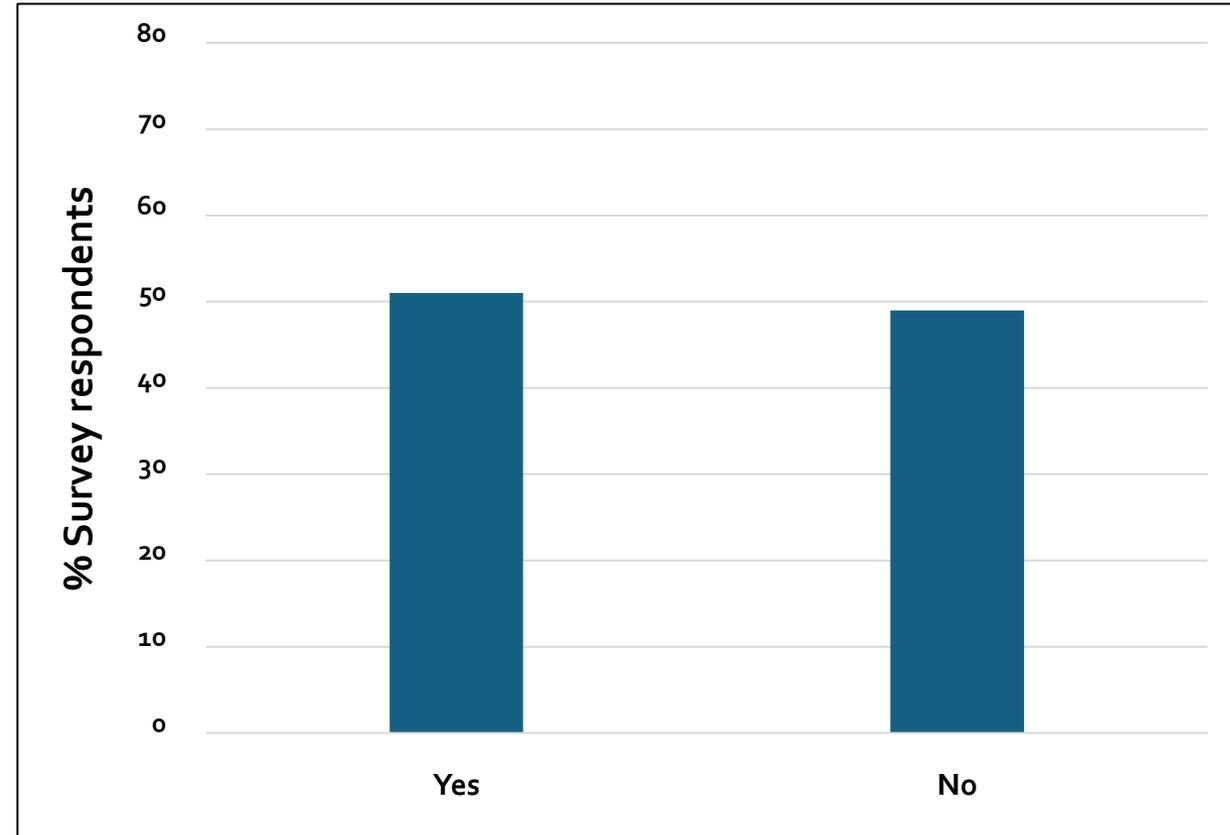
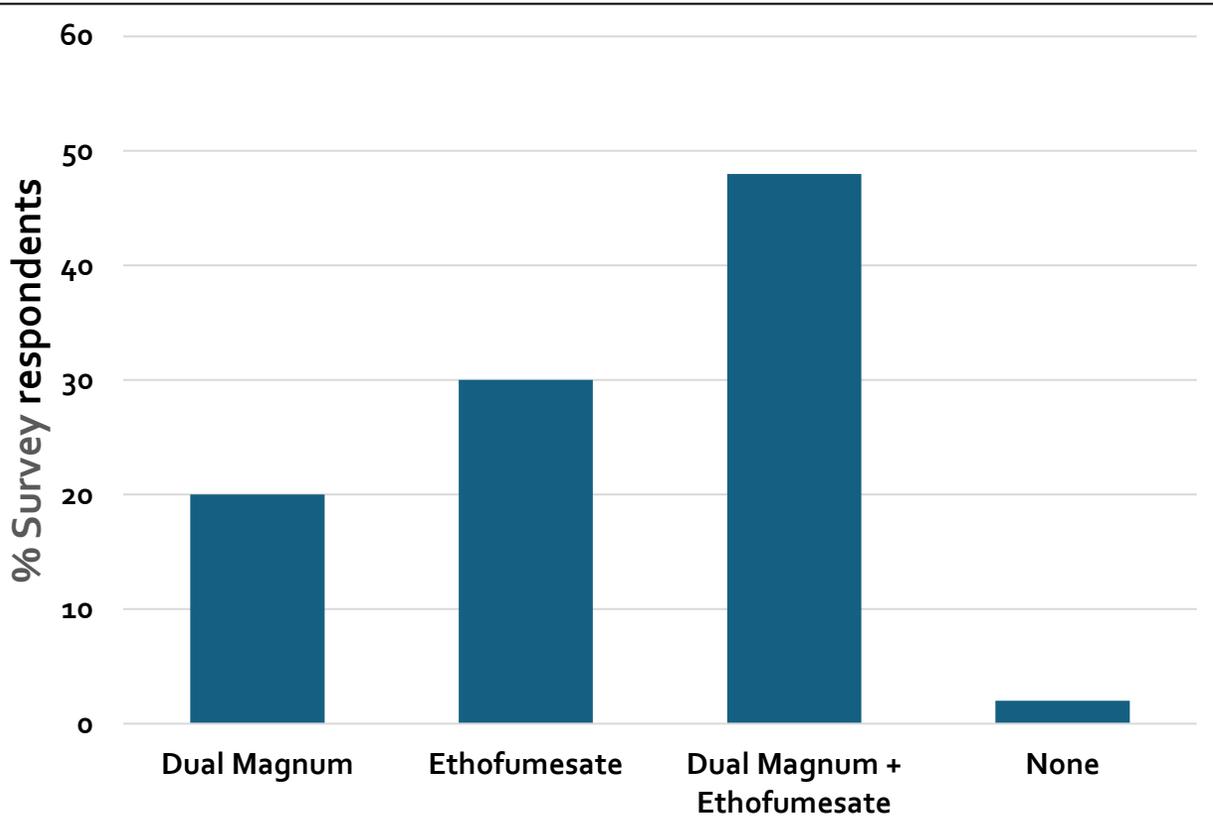
Daily Amounts of Precip



Date	Rainfall (inch)
April 27	1.0
May 20	1.0
June 28	1.0
July 23	1.1
August 5	1.5



# Which soil-applied herbicide did you use at planting? Was ethofumesate activated with tillage?<sup>a</sup>



<sup>a</sup>Turning Point Survey, 2025 Sugarbeet Growers Seminars

# Ethofumesate in 2025

## Group 15

### Ethofumesate brands for sugarbeet production

- Nortron, Bayer CropScience
- Ethotron, UPL NA Inc.
- Ethofumesate 4SC, Farm Business Network
- Maxtron 4SC (3.78 lb/G), ALBAUGH, LLC
- ~~Nektron SC, Atticus, LLC~~



# Ethofumesate 101

- Group 15, Benzofurans sub-family
- Inhibits the biosynthesis of VLCFAs
  - act by inhibiting the growth of meristems
  - retard cell division
  - limits development of leaf cuticles
- Absorbed by the emerging shoots (grass) coleoptile and broadleaf (hypocotyl) and roots with translocation to the foliage.
- Sensitive plants either fail to emerge or remain in an arrested state of growth after emergence
- Degradation is dependent on the properties of soil

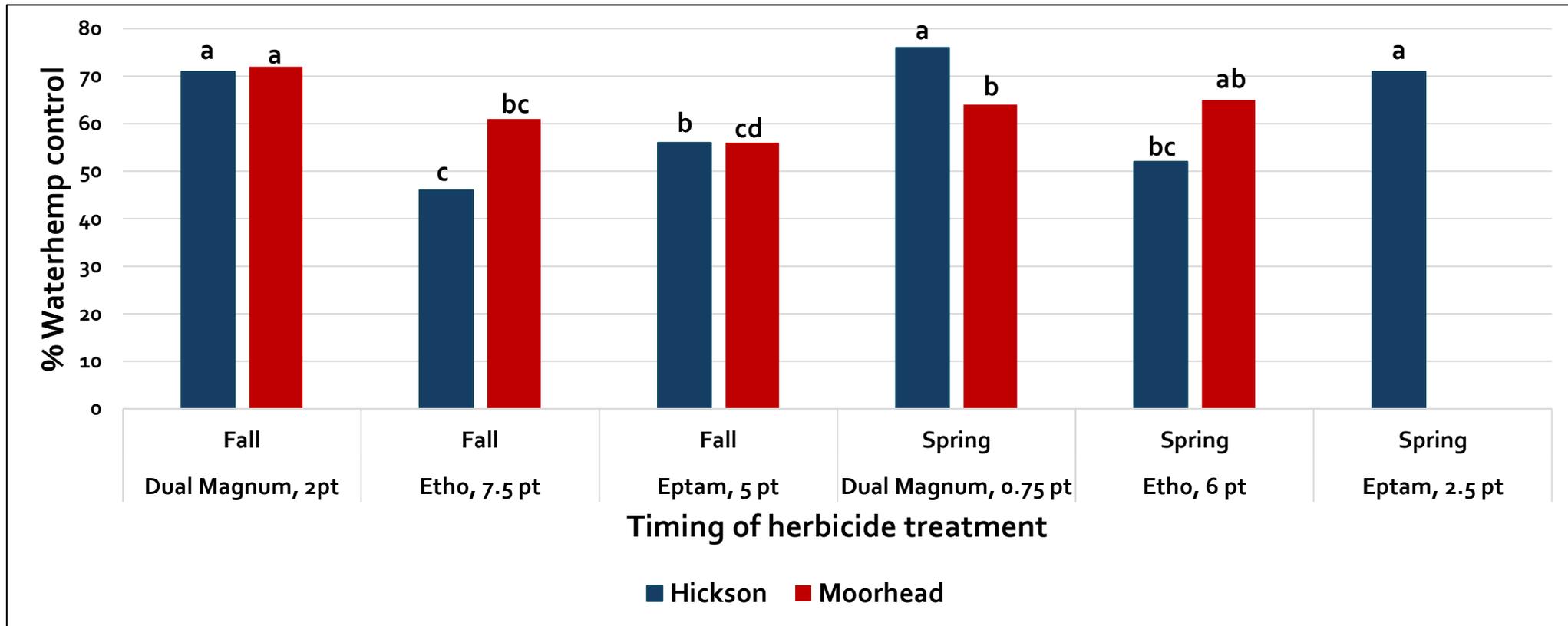


# Ethofumesate 101, continued



- Question. Why is ethofumesate performance inconsistent on waterhemp?
  - As compared to Outlook, ethofumesate has a high KOC value meaning it has a high affinity for binding to soil colloids
  - Ethofumesate is less water soluble than Outlook
- Question. Does rainfall overcome these characteristics?
  - We have increased the use rate
  - We have incorporated ethofumesate
  - Pushing water volume to 20 gpa probably will improve consistency, especially in residue
  - We have attempted fall application to increase the odds of activation
- Question. Does ethofumesate bind to wheat or corn stalk residue?
  - The literature states residue can intercept spray
  - I can't find any information stating etho binds to corn stalks

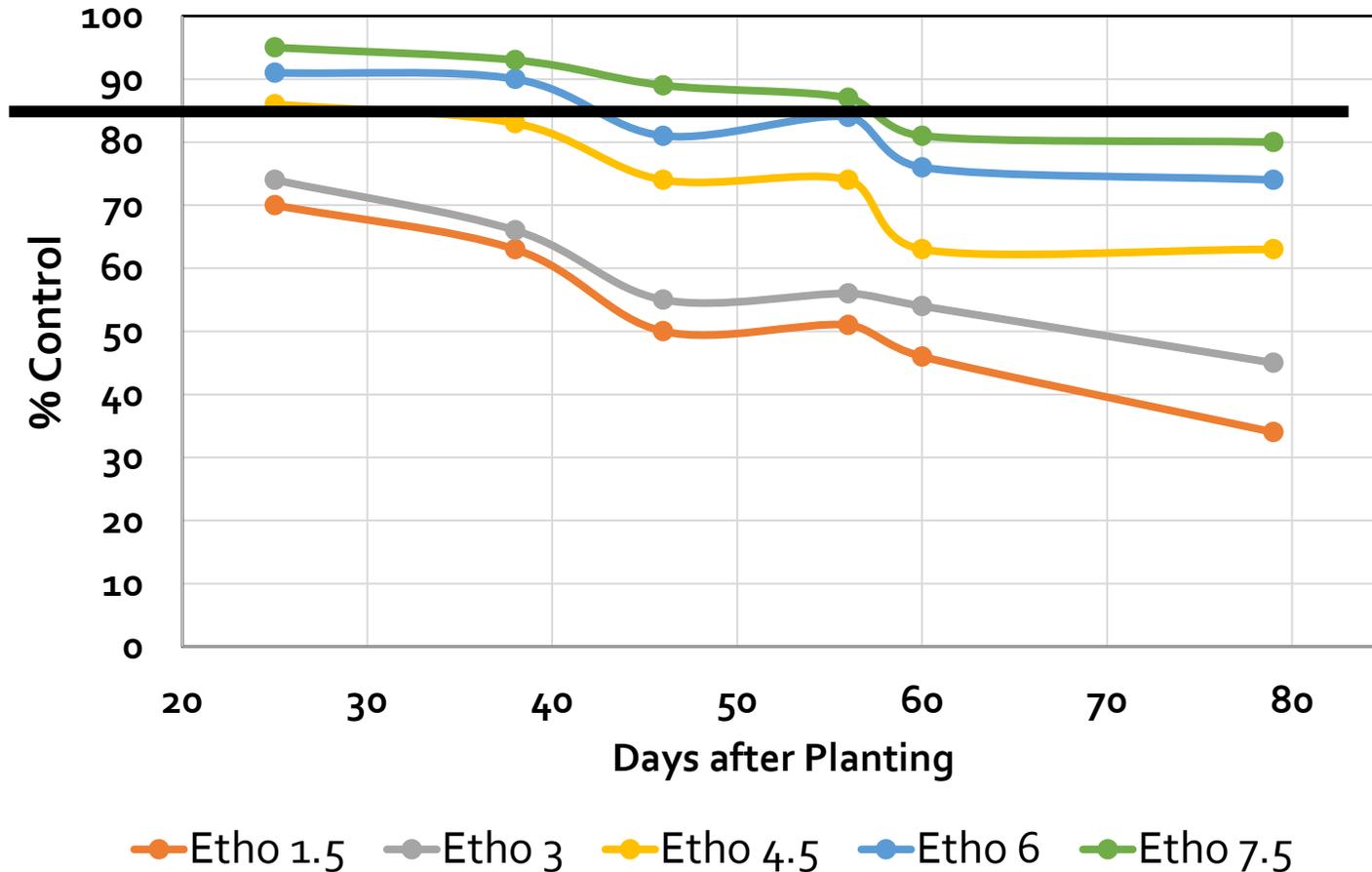
# Waterhemp control in response to fall or spring applied treatment, 71 and 73 DAP, Hickson and Moorhead, 2025.<sup>ab</sup>



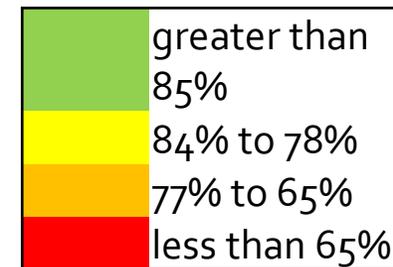
<sup>a</sup>Treatments sharing the same letter are the same at the 0.10 level.

<sup>b</sup>All treatments contained 2-times Roundup PowerMax3 mixed with ethofumesate at the 2- and 6-lf stage.

# Waterhemp control in response to ethofumesate PRE, Lake Lillian, MN, 2020



	Days after planting					
	25	38	46	56	60	79
Etho 1.5	70	63	50	51	46	34
Etho 3	74	66	55	56	54	45
Etho 4.5	86	83	74	74	63	63
Etho 6	91	90	81	84	76	74
Etho 7.5	95	93	89	87	81	80



# What should we use for waterhemp control in 2026?

- Ethofumesate, 4.5 to 6 pt/A
- Dual Magnum at 8 to 12 fl oz/A
- Dual Magnum at 16 lf oz/A after May 1
- Etho + Dual Magnum at 3 pt + 12 fl oz/A

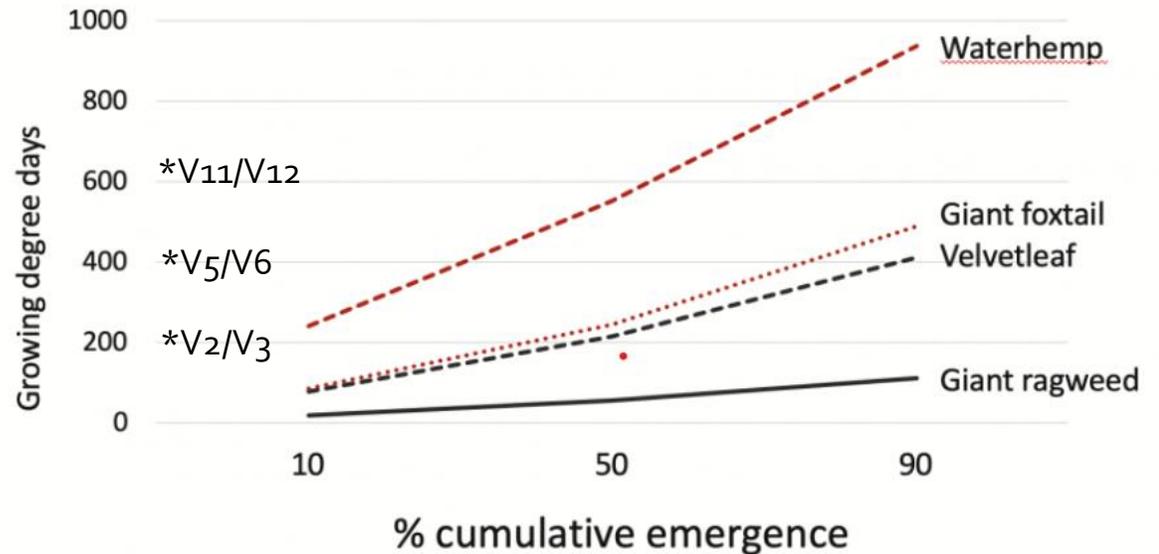


Figure 1. Relationship between growing degree days and emergence of four weeds. Werle, Sandell, Buhler, Hartzler and Lindquist. 2014. Weed Sci. 62:267-279.

The layered residual is strongly contributing to season-long waterhemp control

I think it is time to revisit our layby approach

\*According to Holen and Dexter

# Peters' is proposing...

Herbicide	Previous Rate	Suggestion for 2026	Maximum use rate	Application timing
	fl oz/A	fl oz/A	fl oz or pt/A	Sgbt stage
Outlook / Outlook	12/12	16 to 21	24	12-lf
S-meto / S-meto	16 / 16	20 to 24	2.6 <sup>a</sup>	6od PHI
Acetochlor/ acetochlor <sup>b</sup>	40 to 48 / 40 to 48	48 to 64	8	8-lf

<sup>a</sup>POST maximum use rate. Dual Magnum applied in the fall or PRE is incremental

<sup>b</sup>Warrant or Enversa

I also am **Research only!** (in sugarbeet) and Treflan layby in sugarbeet

# What about etho POST with Roundup PowerMax3? You have 12 fl oz/A to use POST. Use it.

Waterhemp control from postemergence herbicides, across locations and years

Herbicides <sup>1</sup>	Herman 2014	Moorhead 2015	Herman 2015	Lake Lillian 2015	Average
-----% visual control <sup>2</sup> -----					
glyphosate	36	66	20	61	46
glyphosate + ethofumesate	58	81	40	66	61
glyphosate + Betamix	65	86	40	68	65
gly + etho + Betamix	69	88	73	78	78

<sup>1</sup>Roundup alone with Prefer 90 NIS at 0.25% v/v and N-Pak AMS at 2.5% v/v. Roundup tank-mixes with Destiny HC at 1.5 pt/A and N-Pak AMS at 2.5% v/v.

<sup>2</sup>Visual percent waterhemp control at preharvest evaluation

# Waterhemp control results from Truvera™ sugarbeet experiments across years



1. XtendiMax mixed with ethofumesate. XtendiMax offers instant soil residual in a dry spring.
2. XtendiMax early POST. XtendiMax control waterhemp escapes at the 2-lf stage (early lay-by application).
3. A soil residual herbicide POST remains important.
4. The soil residual herbicide should be applied at the 2- to 4-lf stage vs. the 6- to 8-lf stage.
5. Glufosinate mixed with glyphosate at the 6- to 8-lf stage controls waterhemp escapes.



**Untreated Control**



**Etho + XtendiMax/Warrant+RUP+ etho/RUP+etho+gluf**



**Our waterhemp control standard**

**Etho+ Dual Magnum/RUP+etho+ Outlook/RUP+etho+Warrant**



**Etho+XtendiMax/Etho+XtendiMax/RUP+etho+gluf**



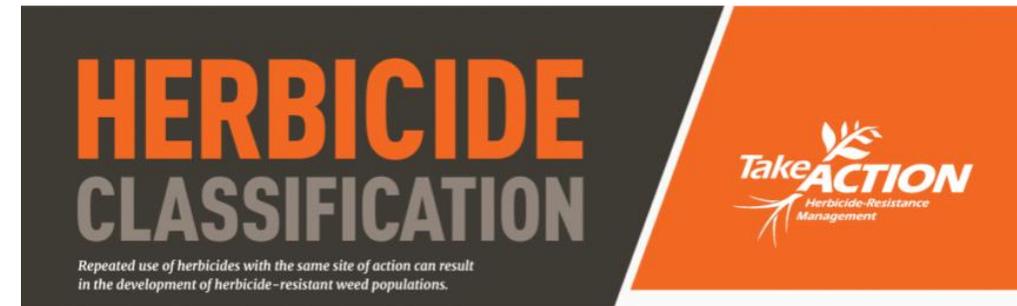
For waterhemp control: need 3-4 effective active ingredients in a program. POST when weeds are less than 3-inch. PRE mandatory for time management constraints and overall effectiveness.

	Wheat	Sugarbeet	Corn	Soybean
PRE	(14)	(15)	(15) (27)	(3) (4) (5) (14) (15)
POST/PRE	(15)	(15)	(15)	(15)
POST	(27) (6) (4)		(4) (5) (27)	(4) (10)

- Lots of 15s
- Not much for waterhemp control in sugarbeet
- Lots of options in soybean; I'm not saying waterhemp control in soybean is easy

# Get back to herbicide basics GROW, <https://growiwm.org>

- What are the most important weeds on your farm?
- Are they herbicide resistant? Which herbicides?
- What herbicides are in the PREMIX?
- What site-of-action group?
- Are the herbicides effective (95% control) against the weeds in your field.
- What is the labeled rate for control? Is the labeled rate the same as the PREMIX rate?
- <https://www.cdms.net/>
- Use the 2026 North Dakota Weed Control Guide to determine rates, % control, rotation restriction for crops in your sequence.



## by MODE OF ACTION (MOA) [effect on plant growth]

This chart groups herbicides by their modes of action to assist you in selecting herbicides 1) to maintain greater diversity in herbicide use and 2) to rotate among effective herbicides with different sites of action to delay the development of herbicide resistance.

SITE-OF-ACTION GROUP	SITE OF ACTION	NUMBER OF RESISTANT WEED SPECIES IN U.S.		
		CHEMICAL FAMILY	ACTIVE INGREDIENT	PRODUCT EXAMPLES (Trade Name)
<b>LIPID SYNTHESIS INHIBITORS</b>				
1	ACASAE INHIBITORS (only for corn)	acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
<b>AMINO ACID SYNTHESIS INHIBITORS</b>				
2	ALS INHIBITORS (nonselective options)	acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
<b>EPSP SYNTHASE INHIBITORS (2-methyl-4-chlorophenyl-5-pyridinyl)</b>				
9	ALS INHIBITORS (selective)	acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
<b>GROWTH REGULATORS</b>				
4	SYNTHETIC AUXINS (2,4-D and related auxin mimics)	acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®
		acetolactate synthase	glyphosate	Roundup®

## by PREMIX

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix's component herbicides and their respective site-of-action groups. Refer to the Site of Action chart on the left for more information.

PREMIX	SITE-OF-ACTION GROUP		PREMIX	SITE-OF-ACTION GROUP	
	ACTIVE INGREDIENT	TRADE NAME		ACTIVE INGREDIENT	TRADE NAME
ACROBAT	glyphosate	Roundup	ACROBAT	glyphosate	Roundup
ACROBAT PLUS	glyphosate	Roundup	ACROBAT PLUS	glyphosate	Roundup
ACROBAT XT	glyphosate	Roundup	ACROBAT XT	glyphosate	Roundup
ACROBAT XT PLUS	glyphosate	Roundup	ACROBAT XT PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS PLUS PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup
ACROBAT XT PLUS PLUS PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup	ACROBAT XT PLUS PLUS PLUS PLUS PLUS PLUS PLUS	glyphosate	Roundup

PULL HERE TO OPEN ►

# RESTRICTED USE PESTICIDE

(GROUND AND SURFACE WATER CONCERNS)

FOR RETAIL SALE TO AND USE ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION, AND ONLY FOR THOSE USES COVERED BY THE CERTIFIED APPLICATOR'S CERTIFICATION.

THIS PRODUCT IS A RESTRICTED-USE HERBICIDE DUE TO GROUND AND SURFACE WATER CONCERNS. USERS MUST READ AND FOLLOW ALL PRECAUTIONARY STATEMENTS AND INSTRUCTIONS FOR USE IN ORDER TO MINIMIZE POTENTIAL FOR ATRAZINE TO REACH GROUND AND SURFACE WATER.

Sale, use and distribution of this product in Nassau and Suffolk Counties in the State of New York is prohibited.



ATRAZINE	GROUP 5	HERBICIDE
BICYCLOPYRONE	GROUP 27	HERBICIDE

MESOTRIONE	GROUP 27	HERBICIDE
S-METOLACHLOR	GROUP 15	HERBICIDE

# Acuron®

Herbicide

Escanee QR para Español



A Herbicide for Control of Annual Grass and Broadleaf Weeds in Field Corn, Seed Corn, Silage Corn, Sweet Corn and Yellow Popcorn

**Active Ingredients:**

S-Metolachlor: (CAS No. 87392-12-9) .....	23.40%
Atrazine*: (CAS No. 1912-24-9) .....	10.93%
Mesotrione: (CAS No. 104206-82-8) .....	2.60%
Bicyclopyrone: (CAS No. 352010-68-5) .....	0.65%

Other Ingredients: .....

**Total:** .....

Acuron® Herbicide is a ZC formulation containing 1.0 pound Atrazine, 0.06 pound Bicyclopyrone, 0.24 pound Mesotrione, and 2.14 pounds S-metolachlor per gallon.

\*Atrazine with a maximum of 0.45% related triazines.

**KEEP OUT OF REACH OF CHILDREN.**

## CAUTION

See additional precautionary statements and directions for use on label.

EPA Reg. No. 100-1466

EPA Est. 100-LA-001

SCP 1466A-L1F 1121

4230207

**2.5 gallons**  
Net Contents

- PPI, PRE, or EPOST
- Rate changes with OM
- Controls numerous important MN and ND weeds including waterhemp
- Flexible
- Reliable
- 18 MONTH ROTATION RESTRICTION TO SUGARBEET

# Case-study, Acuron Herbicide

PREMIX	Active Ingredient	Trade Name	SOA	Effective waterhemp?
Acuron	bicyclopyrone	Optogen	27	✓
	mesotrione	Callisto	27	✓
	atrazine	Aatrex	5	✓
	S-metolachlor	Dual II Magnum	15	✓

What is the use rate for my Amenia, ND Farm?

4% organic matter, 3 qt per acre

Always include Group 5 herbicide with a Group 27 herbicide due to synergy.

What is the herbicide rate in each component in the PREMIX?  
Is the herbicide rate effective for waterhemp control?

Active Ingredient	Trade Name	Rate (lb ai/A in Acuron at 3 qt/A)	Rate for effective control	Effective Herbicide	Comment
bicyclopyrone	Optogen	0.045	0.045	✓	partial control
mesotrione	Callisto	0.188	0.188-0.240	✓	control
atrazine	Aatrex	0.75	2	✓	partial control
S-metolachlor	Dual II Magnum	1.59	1.53	✓	control

# TripleFlex II Herbicide

- PPI, PRE, or EPOST
- Rate changes with OM
- Controls numerous important MN and ND weeds including waterhemp
- One effective waterhemp control herbicide
- 26 MONTH ROTATIONAL RESTRICTION TO SUGARBEET



PREMIX	Active Ingredient	Trade Name	SOA	Effective waterhemp?
TripleFlex	acetochlor	Harness	15	✓
	flumetsulam	Python	2	
	clopyralid	Stinger HL	4	



# More emphasis on glufosinate the last three years

Attribute	Preferred
Droplet size	Medium
Spray volume	20 gpa
Nozzle type	Lots of options
Environmental conditions	Humid, humid, sunny and warm
Adjuvants	?
AMS	YES, I still use dry
Tank-mixes	Yes, with Roundup PowerMax3

# The “Nozzle Compromise”: Select the nozzle producing the correct droplet size for the spray job

Sprayers 101 <https://sprayers101.com>

Tom Wolfe and Jason Deveau

- Herbicide or fungicide?
- Are you applying a contact or translocating herbicide?
- Spray coverage?
- Are you trying to reduce spray drift?
- Does brand or style matter?
- What do the labels say?



# Nozzle Droplet Size Classification

## Color Codes for Droplet Size

Category	Symbol	Color Code	Approx. VMD Range (microns)
Extremely Fine	XF	Purple	<60
Very Fine	VF	Red	60-145
Fine	F	Orange	145-225
Medium	M	Yellow	226-325
Coarse	C	Blue	326-400
Very Coarse	VC	Green	401-500
Extremely Coarse	XC	White	501-650
Ultra Coarse	UC	Black	>650

## Size Comparison:

### Diameter of Common Items (approximate) in Microns

- 2,000  $\mu\text{m}$  #2 pencil "lead"
- 850  $\mu\text{m}$  paper clip
- 420  $\mu\text{m}$  staple
- 300  $\mu\text{m}$  toothbrush bristle
- 150  $\mu\text{m}$  sewing thread
- 100  $\mu\text{m}$  human hair



Based on ASABE 572.1 Standards and referenced in nozzle charts, American Society of Agricultural and Biological Engineers

- I am searching for a medium to course droplet size
- I need good coverage to hit multiple growing points and intend to spray 20 gpa
- I intend to spray at 10 mph
- Nozzle orifice size determined from the table
- Check the label

TIP PART NO. (STRAINER MESH SIZE)	PSI	DROP SIZE	CAPACITY ONE TIP IN GPM	CAPACITY ONE TIP IN OZ/MIN	APPLICATION RATE FOR 20" SPRAY TIP SPACING													
					GALLONS PER ACRE (GPA)								TURF APPLICATION GALLONS PER 1000 SQ. FT.					
					4 MPH	5 MPH	6 MPH	8 MPH	10 MPH	12 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH		
TT11001 (100)	15	VC	0.061	7.8	4.5	3.6	3.0	2.3	1.8	1.5	1.2	0.91	0.21	0.14	0.10	0.08		
	20	C	0.071	9.1	5.3	4.2	3.5	2.6	2.1	1.8	1.4	1.1	0.24	0.16	0.12	0.10		
	30	M	0.087	11	6.5	5.2	4.3	3.2	2.6	2.2	1.7	1.3	0.30	0.20	0.15	0.12		
	40	M	0.10	13	7.4	5.9	5.0	3.7	3.0	2.5	2.0	1.5	0.34	0.23	0.17	0.14		
	50	M	0.11	14	8.2	6.5	5.4	4.1	3.3	2.7	2.2	1.6	0.37	0.25	0.19	0.15		
	60	M	0.12	15	8.9	7.1	5.9	4.5	3.6	3.0	2.4	1.8	0.41	0.27	0.20	0.16		
TT110015 (100)	75	F	0.14	18	10.4	8.3	6.9	5.2	4.2	3.5	2.8	2.1	0.48	0.32	0.24	0.19		
	90	F	0.15	19	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2	0.51	0.34	0.26	0.20		
	15	VC	0.092	12	6.8	5.5	4.6	3.4	2.7	2.3	1.8	1.4	0.31	0.21	0.16	0.13		
	20	VC	0.11	14	8.2	6.5	5.4	4.1	3.3	2.7	2.2	1.6	0.37	0.25	0.19	0.15		
	30	C	0.13	17	9.7	7.7	6.4	4.8	3.9	3.2	2.6	1.9	0.44	0.29	0.22	0.18		
	40	M	0.15	19	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2	0.51	0.34	0.26	0.20		
TT11002 (50)	50	M	0.17	22	12.6	10.1	8.4	6.3	5.0	4.2	3.4	2.5	0.58	0.39	0.29	0.23		
	60	M	0.18	23	13.4	10.7	8.9	6.7	5.3	4.5	3.6	2.7	0.61	0.41	0.31	0.24		
	75	M	0.21	27	15.6	12.5	10.4	7.8	6.2	5.2	4.2	3.1	0.71	0.48	0.36	0.29		
	90	F	0.23	29	17.1	13.7	11.4	8.5	6.8	5.7	4.6	3.4	0.78	0.52	0.39	0.31		
	15	VC	0.12	15	8.9	7.1	5.9	4.5	3.6	3.0	2.4	1.8	0.41	0.27	0.20	0.16		
	20	VC	0.14	18	10.4	8.3	6.9	5.2	4.2	3.5	2.8	2.1	0.48	0.32	0.24	0.19		
TT110025 (50)	30	C	0.17	22	12.6	10.1	8.4	6.3	5.0	4.2	3.4	2.5	0.58	0.39	0.29	0.23		
	40	M	0.20	26	14.9	11.9	9.9	7.4	5.9	5.0	4.0	3.0	0.68	0.45	0.34	0.27		
	50	M	0.22	28	16.3	13.1	10.9	8.2	6.5	5.4	4.4	3.3	0.75	0.50	0.37	0.30		
	60	M	0.24	31	17.8	14.3	11.9	8.9	7.1	5.9	4.8	3.6	0.82	0.54	0.41	0.33		
	75	M	0.27	35	20	16.0	13.4	10.0	8.0	6.7	5.3	4.0	0.92	0.61	0.46	0.37		
	90	F	0.30	38	22	17.8	14.9	11.1	8.9	7.4	5.9	4.5	1.0	0.68	0.51	0.41		
TT11003 (50)	15	VC	0.15	19	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2	0.51	0.34	0.26	0.20		
	20	VC	0.18	23	13.4	10.7	8.9	6.7	5.3	4.5	3.6	2.7	0.61	0.41	0.31	0.24		
	30	C	0.22	28	16.3	13.1	10.9	8.2	6.5	5.4	4.4	3.3	0.75	0.50	0.37	0.30		
	40	M	0.25	32	18.6	14.9	12.4	9.3	7.4	6.2	5.0	3.7	0.85	0.57	0.43	0.34		
	50	M	0.28	36	21	16.6	13.9	10.4	8.3	6.9	5.5	4.2	0.95	0.63	0.48	0.38		
	60	M	0.31	40	23	18.4	15.3	11.5	9.2	7.7	6.1	4.6	1.1	0.70	0.53	0.42		
TT11003 (50)	75	M	0.34	44	25	20	16.8	12.6	10.1	8.4	6.7	5.0	1.2	0.77	0.58	0.46		
	90	F	0.38	49	28	23	18.8	14.1	11.3	9.4	7.5	5.6	1.3	0.86	0.65	0.52		
	15	XC	0.18	23	13.4	10.7	8.9	6.7	5.3	4.5	3.6	2.7	0.61	0.41	0.31	0.24		
	20	VC	0.21	27	15.6	12.5	10.4	7.8	6.2	5.2	4.2	3.1	0.71	0.48	0.36	0.29		
	30	C	0.26	33	19.3	15.4	12.9	9.7	7.7	6.4	5.1	3.9	0.88	0.59	0.44	0.35		
	40	M	0.30	38	22	17.8	14.9	11.1	8.9	7.4	5.9	4.5	1.0	0.68	0.51	0.41		
TT11004 (50)	50	M	0.34	44	25	20	16.8	12.6	10.1	8.4	6.7	5.0	1.2	0.77	0.58	0.46		
	60	M	0.37	47	27	22	18.3	13.7	11.0	9.2	7.3	5.5	1.3	0.84	0.63	0.50		
	75	M	0.41	52	30	24	20	15.2	12.2	10.1	8.1	6.1	1.4	0.93	0.70	0.56		
	90	F	0.45	58	33	27	22	16.7	13.4	11.1	8.9	6.7	1.5	1.0	0.77	0.61		
	15	XC	0.24	31	17.8	14.3	11.9	8.9	7.1	5.9	4.8	3.6	0.82	0.54	0.41	0.33		
	20	VC	0.28	36	21	16.6	13.9	10.4	8.3	6.9	5.5	4.2	0.95	0.63	0.48	0.38		
TT11004 (50)	30	C	0.35	45	26	21	17.3	13.0	10.4	8.7	6.9	5.2	1.2	0.79	0.60	0.48		
	40	M	0.40	51	30	24	19.8	14.9	11.9	9.9	7.9	5.9	1.4	0.91	0.68	0.54		
	50	M	0.45	58	33	27	22	16.7	13.4	11.1	8.9	6.7	1.5	1.0	0.77	0.61		
	60	M	0.49	63	36	29	24	18.2	14.6	12.1	9.7	7.3	1.7	1.1	0.83	0.67		
	75	M	0.55	70	41	33	27	20	16.5	13.8	10.9	8.2	1.9	1.2	0.94	0.75		
	90	F	0.60	77	45	36	30	22	17.8	14.9	11.9	8.9	2.0	1.4	1.0	0.82		
TT11005 (50)	15	XC	0.31	40	23	18.4	15.3	11.5	9.2	7.7	6.1	4.6	1.1	0.70	0.53	0.42		
	20	VC	0.35	45	26	21	17.3	13.0	10.4	8.7	6.9	5.2	1.2	0.79	0.60	0.48		
	30	C	0.43	55	32	26	21	16.0	12.8	10.6	8.5	6.4	1.5	0.97	0.73	0.58		
	40	M	0.50	64	37	30	25	18.6	14.9	12.4	9.9	7.4	1.7	1.1	0.85	0.68		
	50	M	0.56	72	42	33	28	21	16.6	13.9	11.1	8.3	1.9	1.3	0.95	0.76		
	60	M	0.61	78	45	36	30	23	18.1	15.1	12.1	9.1	2.1	1.4	1.0	0.83		
TT11006 (50)	75	M	0.68	87	50	40	34	25	20	16.8	13.5	10.1	2.3	1.5	1.2	0.92		
	90	F	0.75	96	56	45	37	28	22	18.6	14.9	11.1	2.6	1.7	1.3	1.0		
	15	XC	0.37	47	27	22	18.3	13.7	11.0	9.2	7.3	5.5	1.3	0.84	0.63	0.50		
	20	VC	0.42	54	31	25	21	15.6	12.5	10.4	8.3	6.2	1.4	0.95	0.71	0.57		
	30	C	0.52	67	39	31	26	19.3	15.4	12.9	10.3	7.7	1.8	1.2	0.88	0.71		
	40	M	0.60	77	45	36	30	22	17.8	14.9	11.9	8.9	2.0	1.4	1.0	0.82		
TT11006 (50)	50	M	0.67	86	50	40	33	25	19.9	16.6	13.3	9.9	2.3	1.5	1.1	0.91		
	60	M	0.73	93	54	43	36	27	22	18.1	14.5	10.8	2.5	1.7	1.2	0.99		
	75	M	0.82	105	61	49	41	30	24	20	16.2	12.2	2.8	1.9	1.4	1.1		
	90	F	0.90	115	67	53	45	33	27	22	17.8	13.4	3.1	2.0	1.5	1.2		
	15	XC	0.49	63	36	29	24	18.2	14.6	12.1	9.7	7.3	1.7	1.1	0.83	0.67		
	20	VC	0.57	73	42	34	28	21	16.5	14.1	11.5	8.5	1.9	1.3	0.97	0.78		

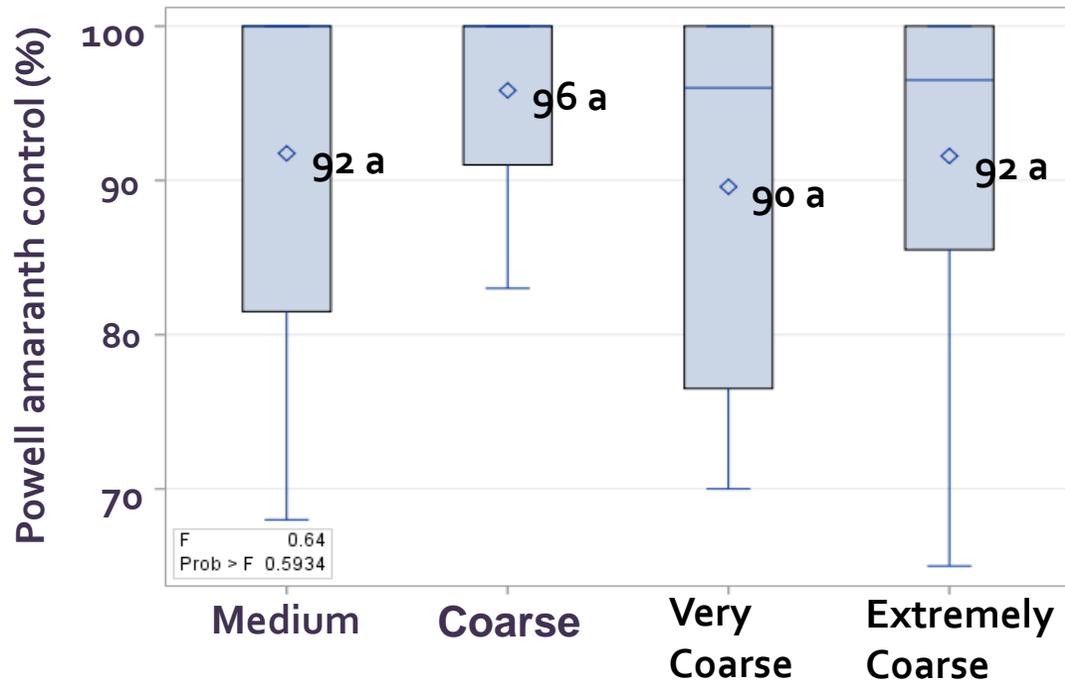
# Droplet size and nozzle manufacturer



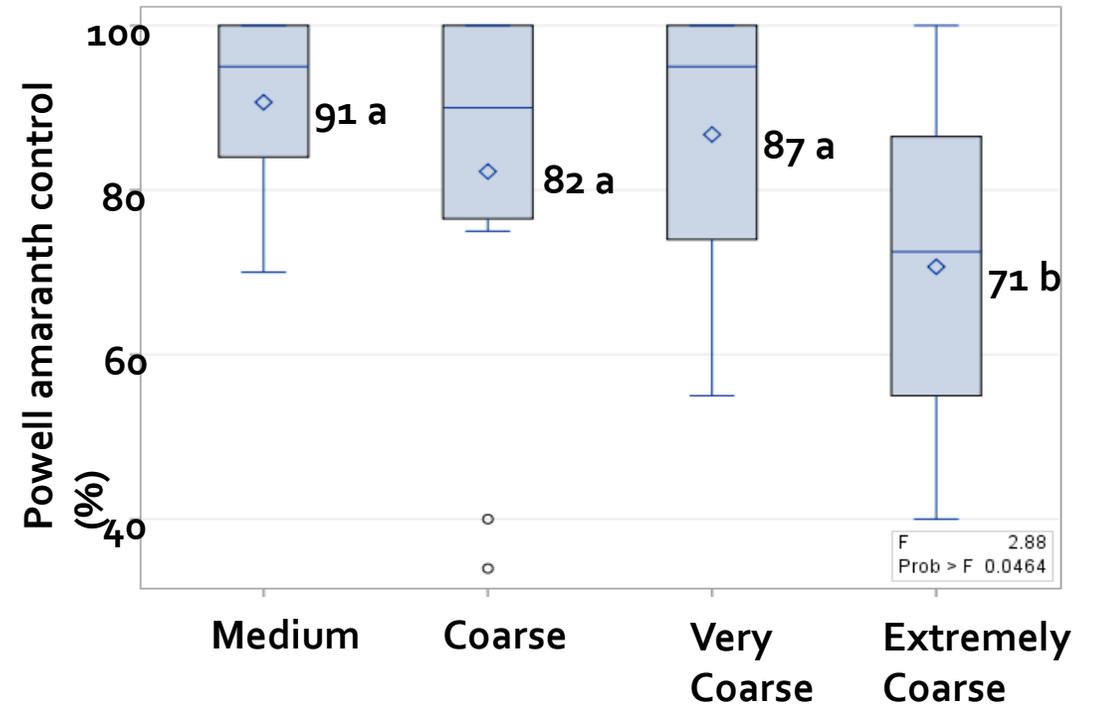
Herbicide(s) <sup>a</sup>	Powell amaranth Control (%)	
	Nozzle Brand A	Nozzle Brand B
Liberty Ultra (29 fl oz/A)	<b>88 b</b>	<b>72 b</b>
Liberty Ultra + Enlist One (32 fl oz/A)	<b>97 a</b>	<b>88 a</b>

<sup>a</sup>MSO (2 pt/A), AMS (3 lbs/A), Anti-Foam (2 oz/100 gal), 10 mph

## Brand A (all 60 psi)



## Brand B (30 to 60 psi)



# Sprayer travel speed

Sprayer travel speeds make a difference on taller and more dense weed populations

Liberty Ultra (29 fl oz/A) plus  
AMS (3 lb/A)

20 GPA

Tall = 10 to 18 inch

Short = < 5 inch

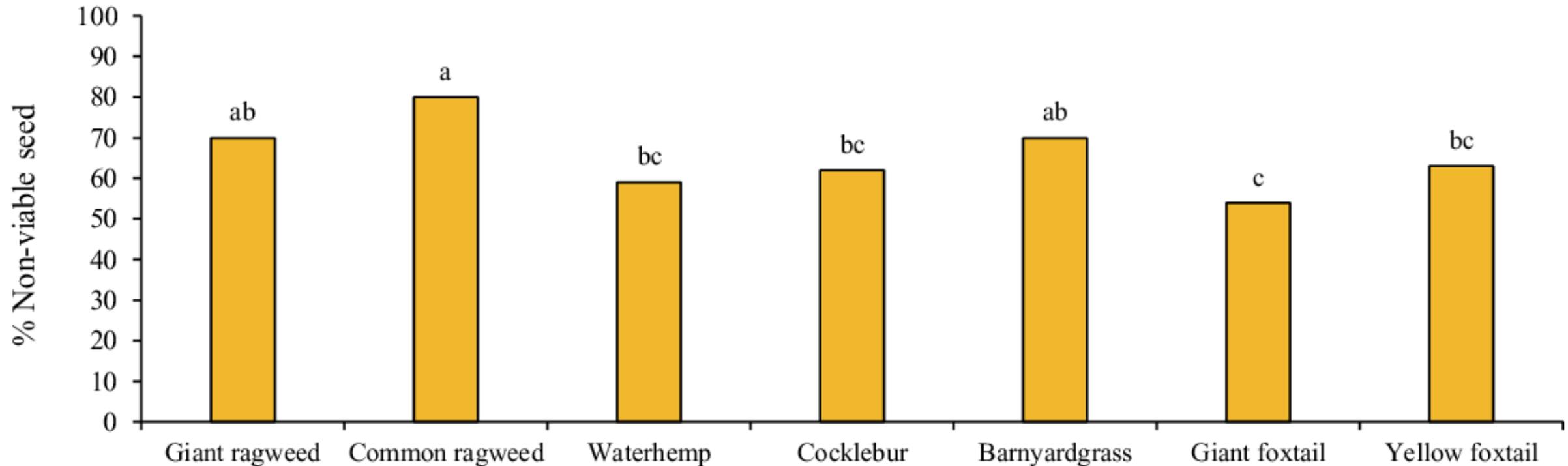
Sprayer Travel Speed	Tall Powell Amaranth	Short Powell Amaranth
mph	-----% Visible control-----	
6	69 AB	88 AB
8	74 A	78 B
10	63 AB	65 C
12	57 B	63 C





Scratch pad new in 2025

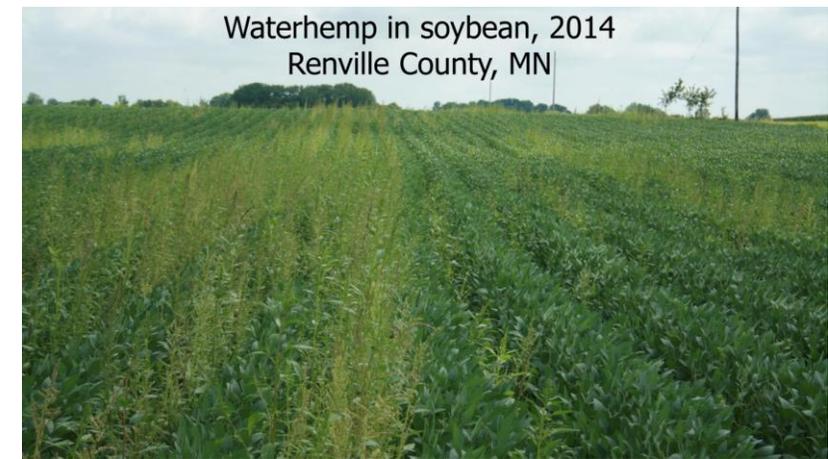
# Electrocution reduces the number of viable seed that are returned to the soil seedbank



Schreier et al. 2022  
Univ. of Missouri



# Herbicide resistance in waterhemp...will it ever end?



# Chloroacetamides in 2024

## Group 15

### **Dimethenamid**

- Outlook, BASF

### **Acetochlor (encapsulated)**

- Warrant, Bayer CropScience
- Enversa, Corteva agriscience
- Arrest CS, Sharda USA LLC

### **S-metolachlor**

- Dual Magnum, Syngenta Crop Protection, LLC
- EverpreX, Corteva agriscience
- Medal, Syngenta Crop Protection, LLC
- Brawl, TENKOZ, Inc.
- Moccasin, UPL NA Inc.
- Charger Basic, WinField United

# Waterhemp response to soil-residual herbicides in Illinois (Hausman et al. 2013)

Active Ingredient	Brand	Rate	Control 60 DAT	Density 60 DAT
		pt/a	%	(plants /unit area)
Acetochlor	Harness	1.7	82 ab	49 defg
Acetochlor	Harness	3.4	88 a	4 g
S-Metolachlor	Dual Magnum	1.6	7 d	215 abc
Untreated Control			-	363 a

<sup>a</sup>Means with the same letter are not significantly different at the 0.05 level

# Dose response curves from the greenhouse

- Different rates across a spectrum, low to high
- Determine rate to reduce 50% of the plant biomass
- Calculate a ratio; resistant to susceptible
- Compare across chloroacetamide products

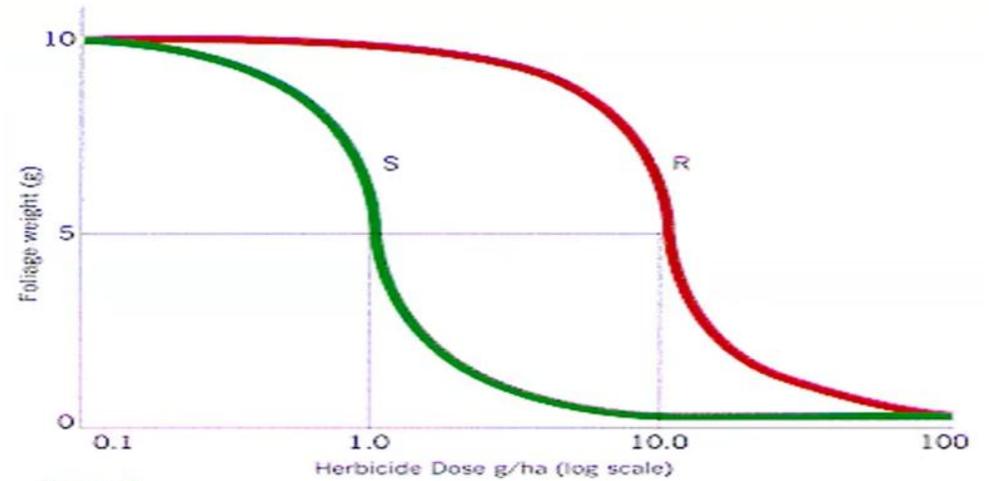


Figure 1. Dose response curves for a Susceptible (S) and a Resistant (R) population

$$ED_{50} (\text{susceptible}) = 1.0 \quad ED_{50} (\text{resistant}) = 10.0$$

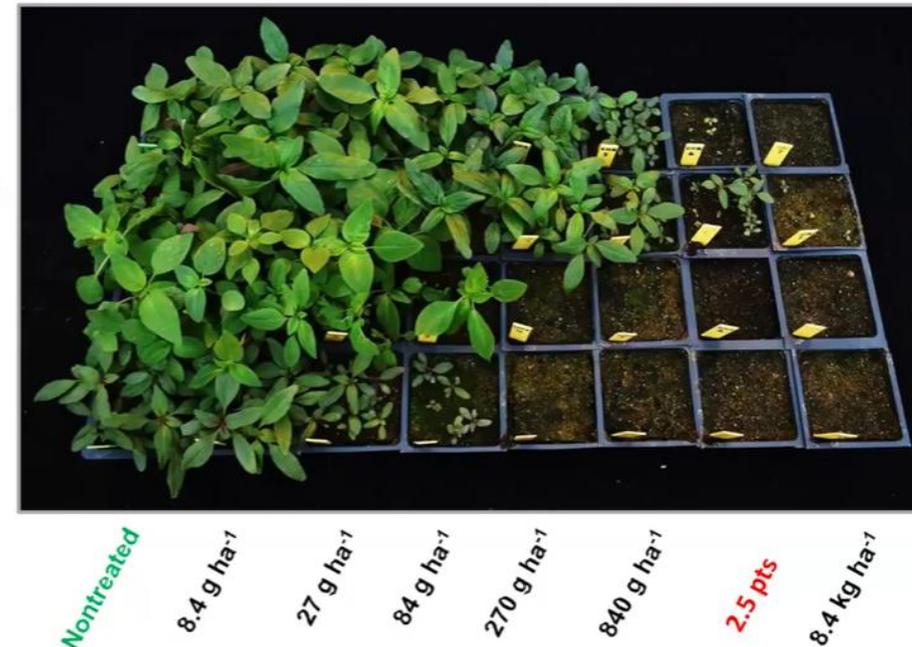
$$\text{Resistance Index} = \frac{ED_{50} (\text{resistant})}{ED_{50} (\text{susceptible})} = \frac{10}{1} = 10$$

Resistance ratios for two Illinois waterhemp populations resistant to Group 15 herbicides. LD<sub>50</sub> values represent the rates required to reduce waterhemp emergence/survival by 50 percent.

Herbicide	Resistant populations (CHR-M6 and MCR-NH40) .....LD <sub>50</sub> (g ai ha <sup>-1</sup> ).....	Sensitive populations (ACR and WUS)	R/S ratio
S-metolachlor	1808–3360	53–101	18–64
dimethenamid	729–1463	26–35	21–56
pyroxasulfone	65–153	9–10	7–17
acetochlor	178–226	13–40	5–18

## Results 21 DAT: Dual II Magnum

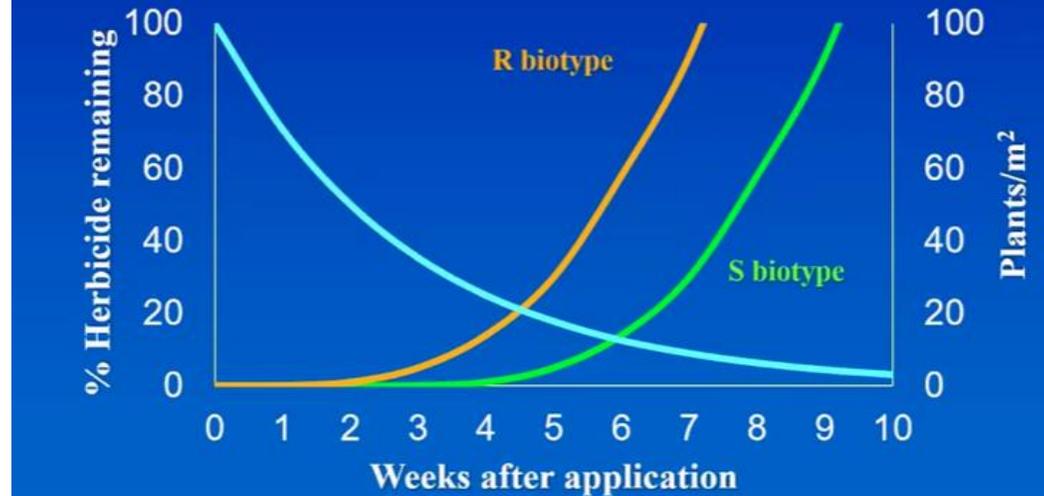
CHR-M6  
MCR-NH40  
WUS  
ACR



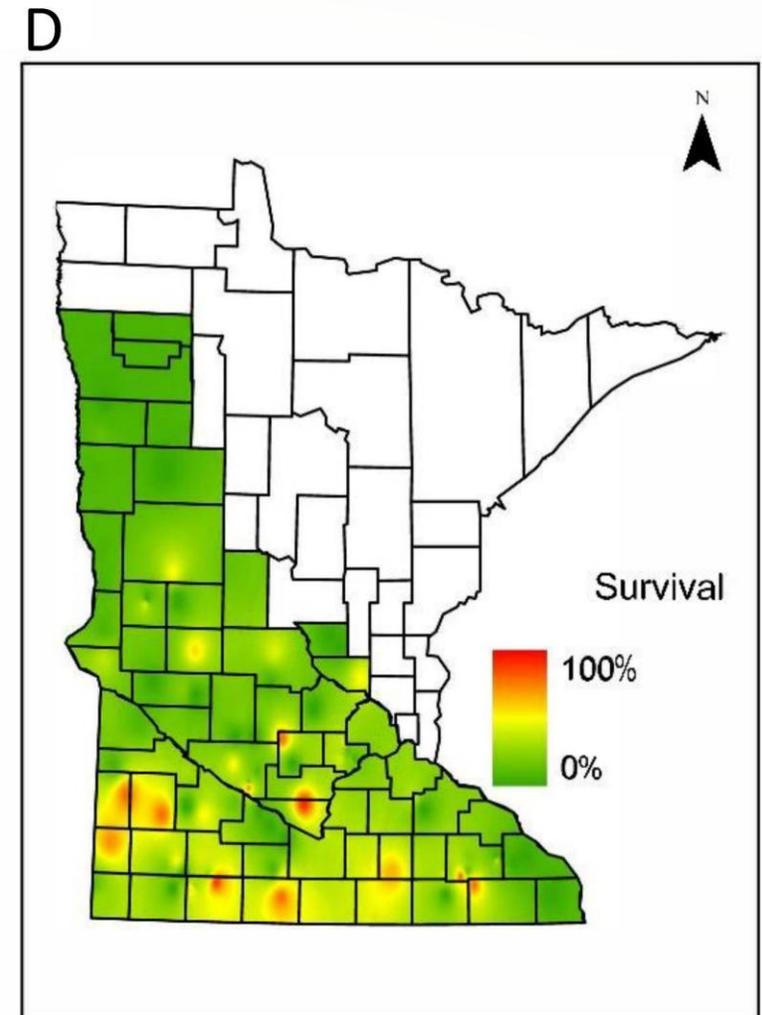
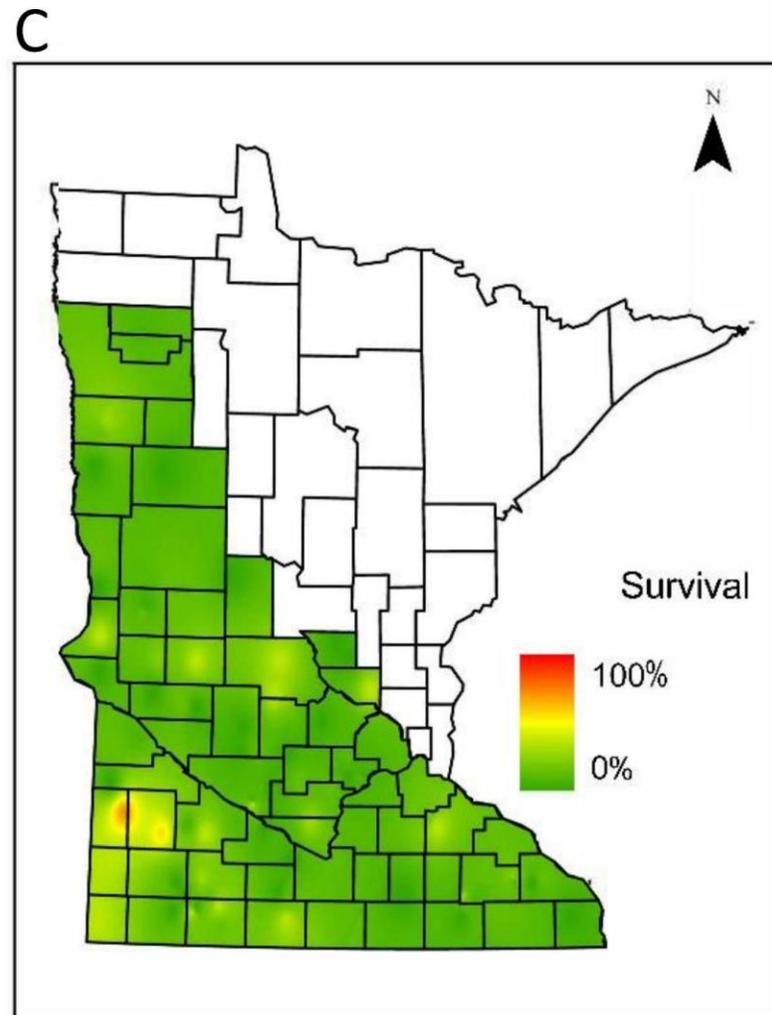
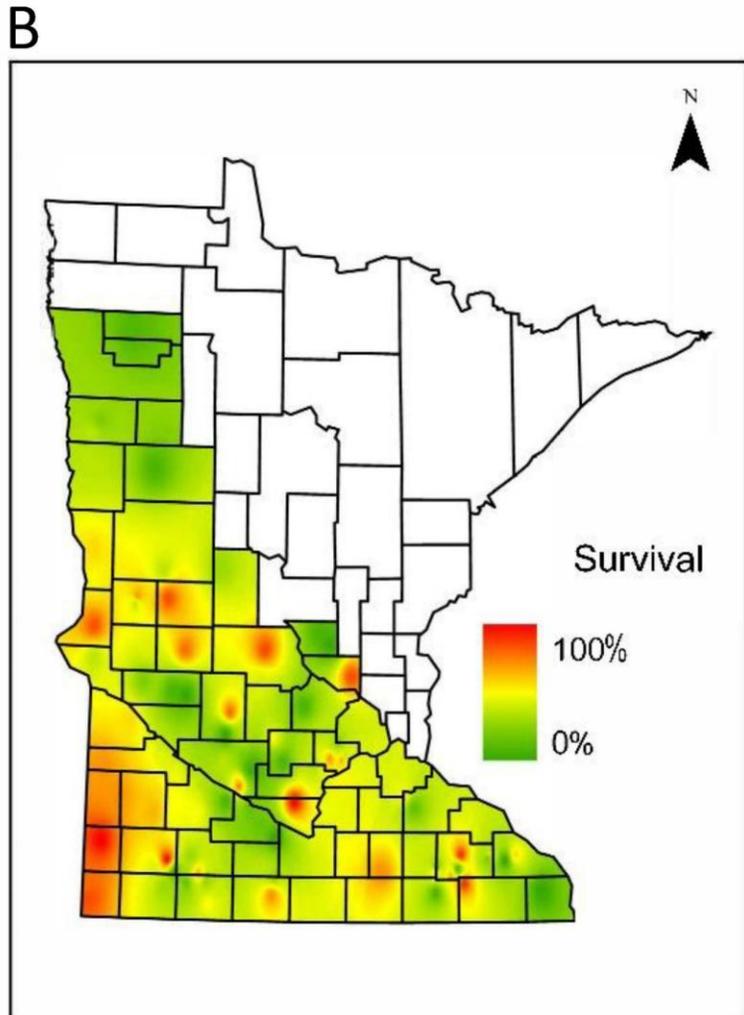
# Resistance implications

- Resistance to foliar herbicides is black and white
  - Rate
  - Size
  - Optimize application conditions
- More difficult with soil applied products
  - Length of residual control is less with resistant populations
  - Soil applied herbicides are dependent on environmental conditions
- Herbicide dissipates over time

## Resistance: What happens to soil-applied herbicides?



# Distribution of herbicide resistant populations: SOA 5 (B), SOA 4 (C), SOA 14 (D), Singh et al., 2024



# How does resistant mapping impact waterhemp control at Minn-Dak Farmers Coop?

- Scout your fields. Be on the look-out for 'observations' that don't make sense
- Take advantage of genetic testing opportunities for seed from escape plants
- Tank-mixes of effective herbicides; use effective herbicides in the crop sequence
- Compliment mechanical and cultural control strategies with your used of herbicides

# Thank you for your continued support

Tom Peters

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