2023 Gold Section: Sugarbeet Weed Control **Page #**

ULTRA BLAZER SECTION 18 EMERGENCY EXEMPTION IN MINNESOTA AND NORTH DAKOTA AND RELATED EXPERIMENTS IN 2023

Thomas Peters[1], Alexa Lystad[2], Emma Burt[3], and David Mettler[4]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist, North Dakota State University & University of Minnesota, Fargo, ND, [3]Graduate Student and Research Agronomist, NDSU and Minn-Dak Farmers Cooperative, and [4]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary

1. Glyphosate (Roundup PowerMax/Roundup PowerMax3) mixed with Ultra Blazer consistently improves waterhemp control from Ultra Blazer.
2. Roundup PowerMax3 mixed with Ultra Blazer increased necrosis and sugarbeet growth reduction injury and reduced root yield and recoverable sucrose as compared with Ultra Blazer alone.
3. Control escape waterhemp less than 4-inches tall with Ultra Blazer at 16 fl oz/A with NIS; control 'train-wreck' situations with Roundup PowerMax3 mixed with Ultra Blazer and AMS.
4. Ninety-five percent of respondents indicated the emergency exemption was beneficial for sugarbeet producers in Minnesota and North Dakota and contributed to overall weed management in 2023.
5. Ninety-two percent of respondents indicated they would willingly support application for a 2024 Ultra Blazer Section 18 emergency exemption in sugarbeet.

Introduction

The Environmental Protection Agency (EPA) approved our request for a Section 18 emergency exemption for Ultra Blazer (acifluorfen) which provided Minnesota and eastern North Dakota sugarbeet growers a postemergence herbicide to control glyphosate-resistant (GR) waterhemp in sugarbeet in 2023. Delayed melt of snow pack, especially in fields adjacent to shelter belts delayed plant. Further, rainfall to activate preemergence herbicides was variable. Finally, above normal maximum daily air temperatures combined with dry conditions caused inconsistent sugarbeet stands in both Minnesota and eastern North Dakota. The average plant date was May 13, May 6, and May 8 for American Crystal Sugar Cooperative (ACS), Minn-Dak Farmers' Cooperative (MDFC), and Southern Minnesota Beet Sugar Cooperative (SMBSC) growers, respectively. With the discontinuance of Betamix, there are currently no registered POST herbicides for effective waterhemp control that escapes soil-residual herbicide treatments.

The exemption allowed a single Ultra Blazer application at 16 fluid ounces per acre per year. A Section 18 exemption under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) authorizes EPA to allow an unregistered use of a pesticide for a limited time if EPA determines that an emergency condition exists. This paper summarizes the Ultra Blazer Section 18 emergency exemption including application parameters and results of a survey completed by agriculturalists and/or sugarbeet growers who applied Ultra Blazer. This report contains three 2023 program objectives: a) summarize results and user experiences from the 2023 Section 18 emergency exemption for use of Ultra Blazer in sugarbeet; b) summarize the Ultra Blazer crop tolerance yield experiment conducted at multiple locations; and c) summarize the Ultra Blazer waterhemp control experiment conducted at multiple locations.

Materials and Methods

Section 18 Emergency Exemption

Ultra Blazer was applied at 16 fl oz/A with non-ionic surfactant (NIS) or mixed with Roundup PowerMax3 and ammonium sulfate (AMS). One Ultra Blazer application was made per season using ground application equipment at 20 to 30 gpa water carrier targeting waterhemp less than 4-inches tall and sugarbeet greater than the 6-lf stage. Pre-harvest interval (PHI) was 45 days and Ultra Blazer was applied from May 22 through July 28, 2022.

Application of Ultra Blazer was targeted when maximum daily air temperatures were less than 85F to reduce injury in sugarbeet. Likewise, producers were informed that sugarbeet injury may be greater following sudden changes from a cool, cloudy environment to a hot, sunny environment. On days when air temperature was greater than 85F, we recommended delaying application until late afternoon or early evening or when air temperatures began to decrease.

Producers and agriculturalists at Southern Minnesota Beet Sugar Coop, Minn-Dak Farmers Coop, and American Crystal Sugar Coop were surveyed by electronic mail to learn more about producer experiences with Ultra Blazer (survey follows in appendix).

Ultra Blazer Tolerance Yield and Waterhemp Control Experiments.
Sugarbeet tolerance experiments were conducted near Crookston, Hendrum, Kent, Lake Lillian, and Murdock, MN in 2023. Waterhemp efficacy experiments were conducted near Moorhead and Blomkest, MN. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at about 62,000 seeds per acre with 4.6 inch spacing between seeds. We had started the Moorhead experiment in a sugarbeet area; however, due to challenges with waterhemp emergence and sugarbeet size, we moved the Moorhead experiment into a bulk fill soybean area to be consistent with waterhemp size at application.

Treatments shown in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 2 and 3.

Table 1. Herbicide treatment, herbicide rate, and application timing across locations in 2023.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	6-8 lf
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	6-8 lf / A + 3-days
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	2 lf / 6 lf

Table 2. Application information for tolerance experiments.

	Crookston	Hendrum	Kent	Murdock	Lake Lillian
Plant Date	May 5	May 16	May 17	May 9	May 4
Application Date	June 8	June 15	June 21	June 9	June 6
Time of Day	10:30 AM	10:00 AM	6:00 PM	12:30 PM	8:00 AM
Air Temperature (F)	72	73	86	73	61
Relative Humidity (%)	56	62	43	57	83
Wind Velocity (mph)	8	3	8	7	6
Wind Direction	SSE	NE	NW	SW	E
Soil Temp. (F at 6”)	70	66	-	-	-
Soil Moisture	Good	Fair	-	-	-
Cloud Cover (%)	50	100	-	-	-

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated approximately 7 and 14 days after treatment (DAT) as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Visible weed control was evaluated 7, 14, and 21 days after the 2-lf stage application using a 0 to 100 scale (0 is no control and 100 is complete control). All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip. Efficacy experimental design was a randomized complete block with four replications.

At harvest for tolerance experiments, sugarbeet was defoliated, harvested mechanically from the center two rows of each plot, and weighed. A root sample (about 20 lbs) was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Tolerance experiment was a was randomized complete block design with six replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Table 3. Application information for efficacy experiments.

	Moorhead	**Blomkest**
Plant Date	May 24	May 22
Application Date	July 5	June 23
Time of Day	7:00 AM	7:00 AM
Air Temperature (F)	67	66
Relative Humidity (%)	43	94
Wind Velocity (mph)	2	2
Wind Direction	-	-
Soil Temp. (F at 6”)	70	70
Soil Moisture	Good	-
Cloud Cover (%)	90	20

Results

Section 18 Emergency Exemption

According to a survey of sugarbeet growers and agriculturalists, Ultra Blazer at 16 fl oz/A was applied to 23,208 sugarbeet acres in 2023 (totaling 2,901 gallons of Ultra Blazer). Eighty percent or 18,512 acres were applied in Minnesota and 20% or 4,696 acres were applied in North Dakota (Tables 4 and 5).

Table 4. Sugarbeet acres sprayed with Ultra Blazer and Ultra Blazer product usage by state.

State	Acres treated	Ultra Blazer	Acifluorfen
		(gallon)	(pound)
Minnesota	18,512	2,314	4,628
North Dakota	4,646	587	1,174
Total	23,208	2,901	5,802

Table 5. Sugarbeet acres sprayed with Ultra Blazer and Ultra Blazer product usage by cooperative.

Cooperative	Acres treated	Ultra Blazer	Acifluorfen
		(gallon)	(pound)
ACSC	4,731.9	591.5	1,183
MDFC	12,500	1,562.5	3,125
SMBSC	5,976	747	1,494
Total	23,208	2,901	5,802

Three observations standout from overseeing the emergency exemption and summarizing observations and agriculturist/producer critiques. First, our producers understand Ultra Blazer is a tool we would prefer not to use. Many agriculturists stated Ultra Blazer does not adequately address our problem or selective control of GR waterhemp escapes; however, it is a necessary tool in emergency situations. Second, Ultra Blazer consistently causes sugarbeet injury but only provides 65% to 80% control (Figure 2). Waterhemp control is strongly influenced by environmental conditions at application and by spray quality or the selection of spray nozzles and carrier volume. Finally, Roundup PowerMax3 mixed with Ultra Blazer caused more sugarbeet injury than with Roundup PowerMax. The restriction of applying Ultra Blazer with Roundup PowerMax3 likely limited the number of growers who utilized this escaped weed control method.

Producers and agriculturalists surveyed reported the Section 18 EE was beneficial for sugarbeet growers and have encouraged Extension Sugarbeet to file for a Section 18 EE in 2024 and to urge UPL NA Inc. to continue towards Section 3 approval for Ultra Blazer in sugarbeet.

Ultra Blazer Tolerance Yield and Waterhemp Control Experiments

Tolerance Yield Experiment. Sugarbeet necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application. All Ultra Blazer treatments caused necrosis injury; however, necrosis injury was greatest from Ultra Blazer at 16 fl oz/A plus crop oil concentrate (COC) at 1.25% v/v and was consistent across locations (Table 6). Similarly, an application of Roundup PowerMax3 mixed with Ultra Blazer plus AMS increased necrosis injury as compared with Ultra Blazer alone. Repeat Ultra Blazer applications of 12 fl oz/A followed by (fb)

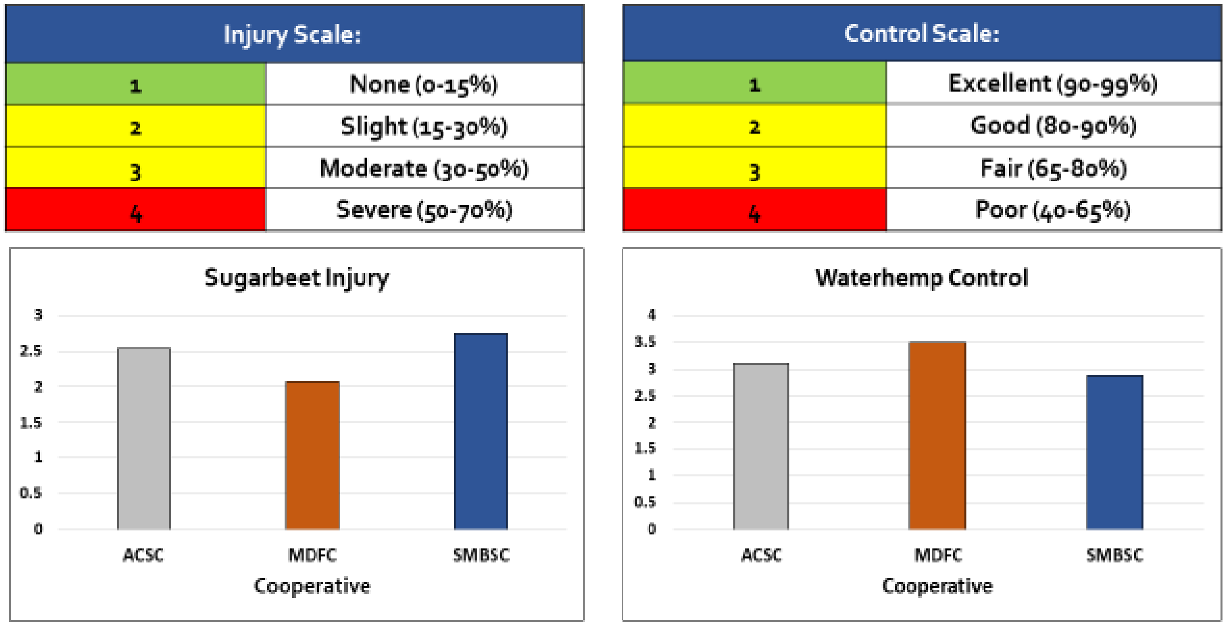

Figure 2. Producer and Agriculturalist survey of sugarbeet injury and waterhemp control from Ultra Blazer Section 18 EE, Minnesota and North Dakota, 2023.

12 fl oz/A gave slightly less necrosis injury than Ultra Blazer at 16 fl oz/A; however, the repeat Ultra Blazer application extended the duration of necrosis injury as compared with a single application.

Necrosis injury from Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS was less than injury from Ultra Blazer plus Roundup PowerMax3 and liquid AMS (Table 6). Sugarbeet necrosis and growth reduction injury from adding Warrant to Ultra Blazer and Roundup PowerMax3 was similar to the Ultra Blazer at 16 fl oz/A plus NIS standard treatment, across locations.

Table 6. Sugarbeet visible injury from herbicide treatments, across locations, 2023.[a]

		Necrosis[b]	Sugarbeet Growth Reduction		
Herbicide Treatment	Rate	3 DAAC[c]	3 DAAC	10 DAAC	20 DAAC
	-----fl oz/A-----	----------------------------------	---%	---------------------------	
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	26 bc	25 b	22 b	13 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	21 b	22 b	33 bc	23 bc
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	49 d	43 c	46 d	34 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	48 d	44 c	43 cd	32 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	35 c	29 b	28 b	18 b
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	1 a	4 a	2 a	3 a
P-Value (0.05)		<0.0001	<0.0001	<0.0001	<0.0001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b] Nec. = Visual necrosis.
[c]DAAC = Days after application C.

Sugarbeet growth reduction injury across treatments averaged 28%, 29%, and 21%, 3, 10, and 20 DAAC, respectively (Table 6). As with necrosis, growth reduction injury was greatest when COC or Roundup PowerMax3 with liquid AMS was mixed with Ultra Blazer. Sugarbeet growth reduction injury from Ultra Blazer at 16 fl oz/A with NIS was similar to sugarbeet injury from 2-times Roundup PowerMax3 applications with NIS and liquid AMS. Two-times Ultra Blazer application at 12 fl oz/A with NIS gave growth reduction injury similar to Ultra Blazer at 16 fl oz/A with NIS; however, injury was greater than injury from the Roundup PowerMax3 control.

Root yield, % sucrose, and recoverable sucrose from Ultra Blazer at 16 fl oz/A plus NIS were the same as two applications of glyphosate alone (Table 7). Root yield and % sucrose from two applications of Ultra Blazer at 12 fl oz/A with NIS were the same as Ultra Blazer at 16 fl oz/A. However, recoverable sucrose from two applications of Ultra Blazer applications at 12 fl oz/A was less than a single application of Ultra Blazer at 16 fl oz/A.

Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS appeared to reduce sugarbeet vegetative injury and yield components as compared with Ultra Blazer mixed with Roundup PowerMax3 and liquid AMS. This is consistent from results in Michigan (personal communication with Dr. Christy Sprague).

Table 7. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across locations, 2023.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	-----fl oz/A-----	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	35.5 ab	17.7	11,180 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	34.2 bc	17.7	10,611 c
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	33.3 c	17.7	10,417 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	33.3 c	17.8	10,430 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	34.9 bc	17.5	10,737 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	37 a	17.8	11,639 a
P-Value (0.05)		0.001	NS	0.001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.

<u>Waterhemp Control.</u> The waterhemp control experiment at Moorhead was terminated and reestablished in soybean. The efficacy experiment was in sugarbeet at Blomkest. Thus, we elected to consider each experiment singly due to the difference in crop species between the two experiments.

Waterhemp control ranged from 40 to 88% at Moorhead, MN and 68 to 93% at Blomkest, MN, 14 DAAC (Table 8). Waterhemp control was or tended to be best when Ultra Blazer was tank mixed with Roundup PowerMax3 plus AMS across locations and evaluations. These results are consistent with results from Ms. Emma Burt's Master of Science research and other results previously communicated. Ultra Blazer plus COC provided or tended to provide waterhemp control similar to Ultra Blazer mixed with Roundup PowerMax3 across locations and evaluations. Two applications of Ultra Blazer at 12 fl oz/A gave better waterhemp control at Blomkest than Moorhead. Conversely, Ultra Blazer plus Roundup PowerMax3 and Warrant plus AMS gave better control at Moorhead than Blomkest.

A repeat application of Ultra Blazer at 12 fl oz/A plus NIS gave waterhemp control similar to a single Ultra Blazer application at 16 fl oz/A plus NIS.

Roundup PowerMax3 provided excellent common lambsquarters control whereas Ultra Blazer provided little or no common lambsquarters control (Table 9). We did not observe any antagonism with common lambsquarters when Ultra Blazer and Warrant were tank mixed with glyphosate.

Table 8. Waterhemp control 7 and 14 days after herbicide treatments, two locations, 2023.[a]

Herbicide Treatment	Rate	Waterhemp Control			
		Moorhead		Blomkest	
		7 DAAC[b]	14 DAAC	7 DAAC	14 DAAC
	-----fl oz/A-----	------------------------------------%------------------------------------			
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	71 b	61 c	79 abc	81 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	74 b	71 c	84 ab	89 ab
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	83 ab	73 bc	88 ab	81 abc
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	91 a	85 ab	93 a	93 a
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	89 a	88 a	75 bc	73 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	43 c	40 d	69 c	68 c
P-Value (0.05)		<0.0001	<0.0001	0.0383	0.0472

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Table 9. Common lambsquarters control 7 and 14 days after herbicide treatments, Moorhead, MN, 2023.[a]

Herbicide Treatment	Rate	Common Lambsquarters Control	
		7 DAAC[b]	14 DAAC
	-----fl oz/A-----	-------------------------%-------------------------	
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	3 d	0 e
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	35 b	10 d
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	23 c	23 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	99 a	94 b
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	99 a	97 ab
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	98 a	98 a
P-Value (0.05)		<0.0001	<0.0001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Conclusion

Controlling weeds in sugarbeet with pesticides continues to be a compromise between sugarbeet injury and weed control. For many years, producers had the luxury of broad-spectrum and uniform weed control with glyphosate and no sugarbeet injury. Glyphosate applied over RR sugarbeet continues to be the safest active ingredient I have evaluated in sugarbeet in my 38-year career, both as a graduate student working with sugarbeet, a representative of industry, and as an academic, developing weed control strategies in sugarbeet. Sugarbeet are not affected by glyphosate rate, adjuvant, growth stage, or environmental conditions.

Glyphosate resistant (GR) weeds forces producers to pursue products that cause greater sugarbeet injury in pursuit of control of escaped weeds. The Section 18 emergency exemption exemplifies the need for Ultra Blazer in sugarbeet but also reveals the crop injury potential and the possibilities for waterhemp regrowth. I support the use of Ultra Blazer for control of weed escapes in sugarbeet. However, it is clear that we need to find ways to improve sugarbeet safety and optimize waterhemp control. Finally, we need to continue to pursue other options for control of

GR weeds. The 2023 (and 2022) Ultra Blazer tolerance yield experiments were designed to determine if sugarbeet injury in response to Ultra Blazer could be reduced, while maintaining or improving waterhemp control through improved water volume, spray nozzle selection, adjuvants or herbicide mixtures. Unfortunately, there is no ‘silver bullet’ with Ultra Blazer.

Appendix. Survey

2023 Ultra Blazer Section 18 Emergency Exemption
Field Observations

Please answer the following questions.

1. What county was Ultra Blazer used for weed control in sugarbeet?____________________

2. How many acres were sugarbeet treated with Ultra Blazer for weed control? ________________

3. Record sugarbeet injury (necrosis or growth reduction) from Ultra Blazer?

   None (0-15%)   Slight (15-30%)   Moderate (30-50%)   Severe (50-70%)

4. Record weed control from Ultra Blazer in sugarbeet?

   Excellent (90-99%)   Good (80-90%)   Fair (65-80%)   Poor (40-65%)

5. Did you observe any unexpected / adverse effects from using Ultra Blazer in sugarbeet?

   YES   NO

6. Did you find the Section 18 to be valuable/useful?

   YES   NO

7. Would you like to use Ultra Blazer again in 2024?

   YES   NO.

Write comments to provide additional details regarding your experiences.

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SUGARBEET TOLERANCE AND WEED CONTROL FROM RO-NEET AND EPTAM IN 2023

Thomas J. Peters[1], Alexa L. Lystad[2], and David C. Mettler[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [3]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary

1. Ro-Neet, Eptam, or Ro-Neet mixed with Eptam at planting caused more sugarbeet injury than ethofumesate at planting.
2. Ro-Neet, Eptam, or Ro-Neet mixed with Eptam provided waterhemp control greater than ethofumesate, 15 and 23 days after planting (DAP).
3. Mixing ethofumesate with either Ro-Neet, Eptam, or Ro-Neet and Eptam might be a way to improve early season waterhemp control, especially when sugarbeet are planted in May or when rainfall is inconsistent.

Introduction

Waterhemp control is our most important weed management challenge in sugarbeet according to the annual growers' survey (Peters et al. 2022). The chloroacetamide herbicides applied at 2- and 6-lf sugarbeet stage are a critical component with our waterhemp control strategy; however, season-long waterhemp control ultimately is dependent on early season control from ethofumesate, Dual Magnum or ethofumesate mixed with Dual Magnum at planting. Some growers are incorporating ethofumesate mostly to ensure activation before waterhemp emergence and to prevent inconsistent waterhemp control (Peters et al. 2022). Ro-Neet, Pyramin, ethofumesate, and Eptam were applied preplant incorporated (PPI) or preemergence (PRE) for weed control in sugarbeet fields in the Red River Valley and Michigan from 1970 to the mid-1980s (Dale et al. 2006). However, use of soil-applied herbicides declined to less than 5% of sugarbeet acres in North Dakota and Minnesota in the mid-1980s because of reliance on POST herbicides and inter-row cultivation (Luecke and Dexter 2003). Stachler and Luecke (2011) reported Ro-Neet, ethofumesate, or Eptam, applied either PPI or PRE, controlled glyphosate-resistant waterhemp; however, they added, sugarbeet growers are reluctant to incorporate herbicides due to detrimental effects of tillage on seed bed moisture and sugarbeet stand.

Sugarbeet growers apply ethofumesate at 3 to 6 pt/A, Dual Magnum at 0.5 to 1 pt/A, or ethofumesate mixed with Dual Magnum at 2 to 3 pt plus 0.5 to 0.75 pt/A, respectively, PRE. These options have provided early season residual control but need to be rainfall activated. Sugarbeet planting was delayed in 2022 and 2023 due to environmental conditions and spring rains have been inconsistent for activating ethofumesate. Thus, growers have opted to incorporate ethofumesate before planting to lessen risk. Incorporating ethofumesate has shifted the mindset and growers are once again asking if Ro-Neet and/or Eptam incorporated might provide more consistent early season waterhemp control than ethofumesate.

Objective

The objective of this experiment was to evaluate weed control and sugarbeet tolerance from Ro-Neet and Eptam alone or in mixtures in comparison with ethofumesate.

Materials and Methods

Experiment was conducted on natural waterhemp populations near Blomkest, MN in 2023. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was planted on May 22, 2023, seeded in 22-inch rows at 60,271 seeds per acre with 4.8 inch spacing between seeds. Herbicide treatments containing Ro-Neet, Eptam, and Ro-Neet + Eptam were two pass incorporated to a 3-inch depth. The first pass was tillage parallel with sugarbeet rows immediately following herbicide application. The second pass was at a shallow angle across the whole trial. Herbicide treatments and rates are described (Table 1). For reasons unknown, Ro-Neet and Eptam rates historically were presented as lb/A rather than pt/A (Table 2).

All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 11002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 35 feet in length. Herbicides were immediately incorporated for each plot with the rows using a field cultivator set 3 inches deep. A second tillage pass was conducted across the entire trial at a 15-degree angle to the rows.

Table 1. Herbicide treatments, rates, and application timing, Blomkest, MN in 2023.

Herbicide treatment	Rate (pt/A)	Timing of Application
Ro-Neet / Roundup PowerMax3 + etho[a,b] /	4.5 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet/ Roundup PowerMax3 + etho /	5.33 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Eptam / Roundup PowerMax3 + etho /	2.29 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Eptam / Roundup PowerMax3 + etho /	2.85 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet+ Eptam / Roundup PowerMax3 + etho /	3.33 + 1.71 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet+ Eptam / Roundup PowerMax3 + etho /	2.67 + 2.29 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ethofumesate / Roundup PowerMax3 + etho /	6 / 25 + 6 /	PRE/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Etho + Dual Magnum[c] / Outlook + Roundup PowerMax3 + etho[c] /	2.5 + 0.75 / 12 + 25 + 6 /	PRE/EPOST/
Warrant + Roundup PowerMax3 + etho	3 + 25 + 6	POST
Ro-Neet+ Eptam + / Warrant + Roundup PowerMax3 + etho /	2.67 + 1.14 / 3 + 25 + 6 /	PPI/EPOST/
Warrant + Roundup PowerMax3 + etho	3 + 25 + 6	POST
Roundup PowerMax3 + etho /	25 + 6 /	EPOST/
Roundup PowerMax3 + Ultra Blazer + Warrant	25 + 16 + 3	POST

[a]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v.
[b]etho = ethofumesate.
[c]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

Visible sugarbeet growth reduction injury was evaluated using a 0 to 100% scale (0% representing no visible injury and 100% as complete loss of plant / stand) approximately 7 and 14 days (+/- 3 days) after sugarbeet emergence and 7 and 14 days (+/- 3 days) after early POST (EPOST) application. The combination of two-pass incorporation and dry soils created some gaps in stands. Estimates of stand were collected to separate effects from herbicides and lack of stand associated with dry soils. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) 14 and 21 days (+/- 3 days) after PPI/PRE (application A/B) and 7, 14, 21, and 40 days and after EPOST/POST (application C/D). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2023.5 software package.

Table 2. Eptam and Ro-Neet treatments expressed as pt/A and lb/A.

Treatment	Rate	
	---pt/A---	---lb/A---
Ro-Neet	4.50	3.4
Ro-Neet	5.33	4.0
Eptam	2.29	2.0
Eptam	2.85	2.5
Ro-Neet + Eptam	3.32 + 1.71	2.5 + 1.5
Ro-Neet + Eptam	2.67 + 2.29	2.0 + 2.0
Ro-Neet + Eptam	2.67 + 1.14	1.0 + 1.0
Ethofumesate	6	3.0

Results and Discussion
Sugarbeet growth reduction ranged from 13% to 50%, 16 days after application A (DAAA) and 3% to 20%, 32 DAAA (Table 3). We observed the greatest sugarbeet growth reduction from treatments with Eptam alone and Eptam mixed with Ro-Neet. Sugarbeet injury 24 or 32 DAAA was less than sugarbeet injury 16 DAAA. These results are consistent with Dr. Alan Dexter's observations that Eptam may reduce sugarbeet stands and cause reduced sugarbeet stands and temporary early season growth reduction, especially on coarse textured and low organic matter soils (personal communication).

We observed minor sugarbeet growth reduction with ethofumesate mixed with Dual Magnum, our standard lay-by program (Table 3). However, we attribute observed lack of uniformity in stand to lack of rainfall throughout the growing season. Weekly rainfall totals collected weekly after planting from on-site instrumentation are in Table 4.

Table 3. Sugarbeet growth reduction from herbicide treatments, Blomkest, MN in 2023.[a]

		Sugarbeet Growth Reduction		
Herbicide treatment	**Rate**	**16 DAAA[b]**	**24 DAAA**	**32 DAAA**
	-------pt/A-------	-----------------------	---%---	-----------------------
Ro-Neet / RUPM3[c] / RUPM3	4.5 / 25 / 25	29 abc	8 abcd	3 a
Ro-Neet/ RUPM3 / RUPM3	5.33 / 25 / 25	25 ab	0 a	5 ab
Eptam / RUPM3 / RUPM3	2.29 / 25 / 25	50 d	10 bcd	14 bcd
Eptam / RUPM3 / RUPM3	2.85 / 25 / 25	48 d	14 cd	20 d
Ro-Neet + Eptam / RUPM3 / RUPM3	3.33 + 1.71 / 25 / 25	36 bcd	3 ab	13 bcd
Ro-Neet + Eptam / RUPM3 / RUPM3	2.67 + 2.29 / 25 / 25	40 bcd	15 d	13 bcd
Ethofumesate / RUPM3 / RUPM3	6 / 25 / 25	24 ab	0 a	5 ab
Ethofumesate + Dual Magnum / Outlook + RUPM3[d] / Warrant + RUPM3	2.5 + 0.75 / 12 + 25 / 3 + 25	13 a	10 bcd	10 abc
Ro-Neet + Eptam / Warrant + RUPM3 / Warrant + RUPM3	2.67 + 1.14 / 3 + 25 / 3 + 25	45 cd	13 cd	15 cd
RUPM3 + etho / RUPM3 + Ultra Blazer + Warrant[e]	25 / 25 + 16 + 3	18 a	6 abc	3 a
LSD (0.10)		**17**	**8**	**9**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]DAAA = Days after application A.
[c]RUPM3=Roundup PowerMax3. POST Roundup PowerMax3 applied with ethofumesate at 6 fl oz/A.
[d]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC and Amsol Liquid AMS at 1.5 pt/A + 2.5% v/v.
[e]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

We evaluated sugarbeet stand using a 1 to 9 scale; 1 representing little to no stand and 9 representing a complete stand and sugarbeet canopy on a percent ground cover basis using a 0% to 100% scale in our attempt to discern sugarbeet injury caused by herbicide from stand variation caused by dry moisture conditions. Overall, sugarbeet stands averaged roughly 7, which is classified as a good stand (Table 4). Sugarbeet canopy tended to be less from Eptam alone or Eptam mixtures (Figure 1).

Table 4. Weekly rainfall measurements beginning May 22, 2023, Blomkest, MN.[a]

Week	Herbicide Application	Rainfall (inch)
1: May 22	PPI and PRE	0.0
2: May 29		0.2
3: June 5	2-lf sugarbeet stage	1.0
4: June 12		0.3
5: June 19	8-lf sugarbeet stage	0.7
6: June 26		0.0
7: July 3		0.6
8: July 10		1.0
9: July 17		0.0
	Cumulative total:	**3.8**

[a]Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific, Inc., Logan, UT.

Waterhemp control from herbicide treatments was observed weekly between June 7 and July 31, 2023, or 15 to 69 days following planting and 0 to 53 days following the first postemergence glyphosate application. This summary will focus on waterhemp and common lambsquarters control 23, 31, and 52 days after planting, or 7, 15, and 36 days after the first postemergence application, when waterhemp control across treatments averaged 81%, 82%, and 66%, respectively (Table 5). Our sugarbeet standard for waterhemp control, ethofumesate followed by (fb) Outlook+ RUPM3+etho fb Warrant+RUPM3+etho applied at planting and at the sugarbeet 2- and 6-lf stage fell below the experiment averages. We attribute this to the lack of activating rainfall after planting. In general, waterhemp control was best from treatments containing Ro-Neet, Eptam or Ro-Neet mixed with Eptam, 7 and 15 DAAC. Waterhemp control was similar across treatments 36 DAAC.

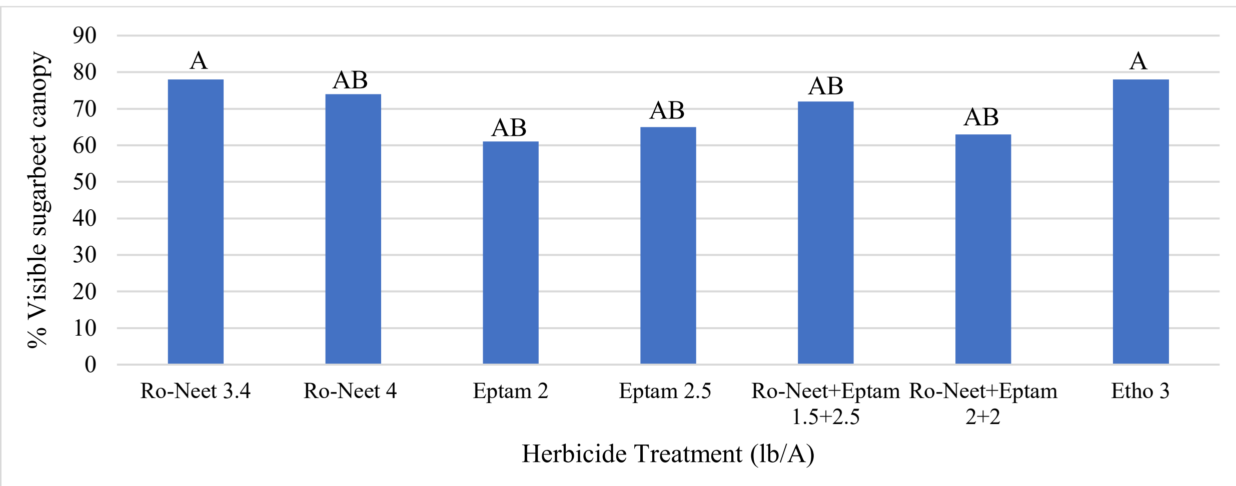

Figure 1. Sugarbeet canopy from selected treatments, 53 days after plant (DAP) or at canopy closure, Blomkest, 2023.

Treatment 9 was Ro-Neet + Eptam followed by Warrant at 3 pt/A applied at the 2-lf sugarbeet stage. Treatment 9 also contained glyphosate + ethofumesate applied at the 2- and 6-lf stage. Although it is difficult to observe benefits from the layby program in a dry year, we intend to continue to evaluate this concept in 2024.

We were able to evaluate common lambsquarters in the experiment; however, Roundup PowerMax3 provided complete control of all common lambsquarters in the POST applications.

Conclusions

We observed the greatest numeric waterhemp control from Eptam at 2.29 and 2.85 pt/A; however, these rates resulted in close to 50% growth reduction, 16 DAAA. Ethofumesate at planting followed by two times Roundup PowerMax3 and ethofumesate or ethofumesate followed by Outlook or Warrant with Roundup PowerMax3 and ethofumesate provided less waterhemp control compared with treatments containing Eptam, Ro-Neet, or both. We have stated ethofumesate probably did not provide at planting waterhemp control due to the dry conditions at and after planting. However, those are the conditions our growers planted into in 2023 and we need to develop reliable programs, regardless of environmental conditions. For the 2024 growing season, we intend to further evaluate Eptam and/or Ro-Neet mixed with ethofumesate to develop more consistent early season waterhemp control.

Table 5. Waterhemp control from herbicide treatments, Blomkest, MN in 2023.[a]

		Waterhemp Control		
Herbicide treatment	**Rate**	**7 DAAC[b]**	**15 DAAC**	**36 DAAC**
	----------pt/A----------	----------------------%----------------------		
Ro-Neet/ RUPM3[c] / RUPM3	4.5 / 25 / 25	89 a	88 a	68
Ro-Neet/ RUPM3 / RUPM3	5.33 / 25 / 25	79 bc	84 a	65
Eptam / RUPM3 / RUPM3	2.29 / 25 / 25	91 a	88 a	66
Eptam / RUPM3 / RUPM3	2.85 / 25 / 25	89 a	86 a	73
Ro-Neet+ Eptam / RUPM3 / RUPM3	3.33 + 1.71 / 25 / 25	90 a	89 a	68
Ro-Neet+ Eptam / RUPM3 / RUPM3	2.67 + 2.29 / 25 / 25	92 a	89 a	76
Ethofumesate / RUPM3 / RUPM3	6 / 25 / 25	63 d	63 b	49
Ethofumesate + Dual Magnum / Outlook + RUPM3[d] / Warrant + RUPM3	2.5 + 0.75 / 12 + 25 / 3 + 25	75 c	83 a	61
Ro-Neet+ Eptam / Warrant + RUPM3 / Warrant + RUPM3	2.67 + 1.14 / 3 + 25 / 3 + 25	85 ab	88 a	68
RUPM3 + etho / RUPM3 + Ultra Blazer + Warrant[e]	25 / 25 + 16 + 3	55 d	64 b	68
LSD (0.10)		**9**	**11**	**NS**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]DAAC = Days after application C.
[c]RUPM3=Roundup PowerMax3. POST Roundup PowerMax3 applied with ethofumesate at 6 fl oz/A.
[d]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC and Amsol Liquid AMS at 1.5 pt/A + 2.5% v/v.
[e]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

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A COMPENDIUM OF OUR ETHOFUMESATE KNOWLEDGE

Thomas J. Peters[1] and Alexa L. Lystad[2]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, and [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND

Summary

1. Ethofumesate might be our most important sugarbeet herbicide; however, it is our least understood sugarbeet herbicide.
2. Ethofumesate applied at greater than 2 pt/A will reduce stands of nurse crops including spring barley.
3. Early season waterhemp control from ethofumesate is dependent on rainfall or mechanical tillage for activation. Rainfall provides the best quality activation but has been unreliable, especially in years with late sugarbeet planting.
4. Our research supports ethofumesate alone applied either at 4 or 6 pt/A or tank mixed with Dual Magnum for early season waterhemp control.

Introduction

We have designed and conducted many ethofumesate experiments. Our experiments consider many facets of ethofumesate including reduced rates combined with Dual Magnum for waterhemp control, potential to injure nurse crops, and amount of rainfall required for activation. More recently we have compared ethofumesate preplant and preemergence, especially since spring rainfall for activation has been inconsistent. This compilation completes a series of five experiments conducted from 2020 to 2023 comparing waterhemp control and spring barley injury from ethofumeste applied up to 12 pt/A preplant or preemergence.

<u>Nurse crop safety.</u> Growers frequently ask if ethofumesate can be used safely with a nurse crop. Nurse crops are used as companion crops to reduce effect of blowing soil on sugarbeet. Stated another way, growers want to know the trade-off between using a soil residual herbicide for waterhemp control versus a successful establishment of nurse crops. We learned nurse crops respond differently to ethofumesate and Dual Magnum, that spring wheat and barley are more sensitive than oat (Peters et al. 2015). Second, nurse crops tolerate Dual Magnum better than ethofumesate, although both Dual Magnum and ethofumesate inhibit the root and apical meristem in susceptible species. The difference is Dual Magnum is metabolized faster than ethofumesate by cereals. However, there are situations where Dual Magnum and ethofumesate cause minimal stand loss to cover crops; situations where rainfall fails to incorporate herbicides into the soil for uptake by emerging shoots or developing roots. We have received questions regarding winter rye as a cover crop (fall seeded) and winter rye as a nurse crop (spring seeded). To be clear, we have not evaluated rye tolerance to ethofumesate; however, I anticipate no injury from fall-seeded rye and less injury from spring-seeded rye as compared with oat, spring wheat, or barley.

<u>Activation.</u> Challenges with activating soil residual herbicides have been commonplace since 2021. Conditions were so poor that the experiment at Moorhead was abandoned due to erratic emergence of spring barley and we observed very poor overall control of waterhemp at the Fargo location in 2021. Waterhemp escapes were either small or big plants, depending on treatment, suggesting control of either early or late emerging waterhemp. Ethofumesate preplant provided no control of early emerging waterhemp, but 56% control of late emerging waterhemp. Conversely, ethofumesate preemergence provided 55% control of early emerging waterhemp, but only 28% control of late emerging waterhemp. We hypothesize that ethofumesate incorporated into the soil was bound to soil colloids and unavailable for waterhemp uptake early in the season due to sub-optimal soil moisture conditions (Figure 1). Ethofumesate moved into the soil solution following rain events in early June and was partially effective at controlling later emerging waterhemp. Ethofumesate PRE likely was bound to the soil surface and may have moved into the soil following these rainfall events in late May and early June, providing some early season control. However, degradation likely reduced control of late emerging waterhemp.

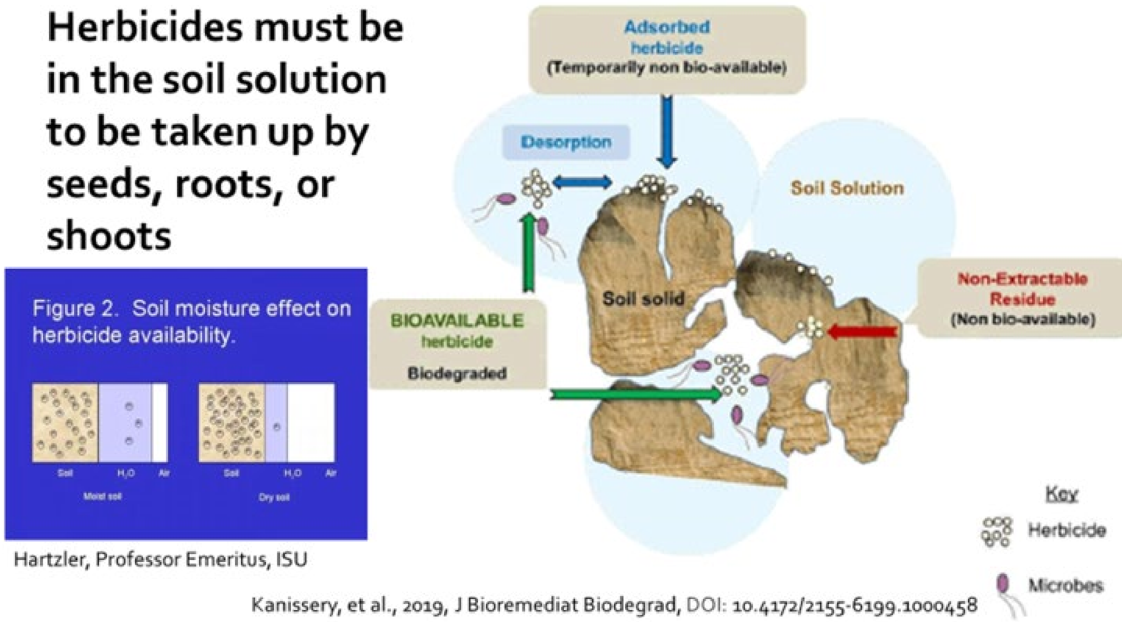

Figure 1. Illustration depicting ethofumesate bound to soil colloids when soil water content is low and in the soil solution when the soil water content is greater.

Our hypothesis is supported by the physical properties of ethofumesate compared with other herbicides (Table 1). KOC value of 350 for ethofumesate means that it has a high affinity for soil colloids and would rather be bound to soil than be in the soil solution as compared with other chloroacetamide herbicides. Second, water solubility value of 110 means ethofumesate is less water soluble than other chloroacetamide herbicides and requires more rainfall (quantity and intensity) to be incorporated into the soil. Further, we believe rainfall and soil moisture (above and below) are a predictor of waterhemp control from ethofumesate and at least partially explains the inconsistent results growers have experienced when ethofumesate has been applied preemergence in some fields in previous years. Finally, ethofumesate controls waterhemp best following timely, adequate, and penetrating rainfall events to move ethofumesate off the soil surface and into the water solution and/or spaces between colloids.

Table 1. Herbicide absorptivity (KOC) and water solubility (ppm).

Herbicide	Absorptivity	Water Solubility
	---K_{OC}[a]---	---ppm---
Treflan	7,000	0.3
Dicamba	2	4,500
Acetochlor	200	233
Outlook	155	1,174
S-metolachlor	200	488
Ethofumesate	340	110

[a]The K value represents the ratio of herbicide bound to soil collides versus what is free in the water. Thus, the higher the K value, the greater the adsorption to soil colloids.

Waterhemp control. Ethofumesate has not provided season-long waterhemp control in our, or previous NDSU, sugarbeet research. Further, growers are reluctant to use full rates preplant or preemergence due to price, specter of carryover to grass crops planted in sequence with sugarbeet, and injury potential to nurse crops. Rather, growers have adopted an integrated strategy whereby chloroacetamide herbicides applied POST to sugarbeet and PRE to waterhemp in a single or split application at the V2 and/or V6 sugarbeet stage precede application PRE. Ethofumesate alone or ethofumesate mixed with Dual Magnum are applied PRE at less than full rates. We teach that PRE is not providing season long control, but rather is a layer to protect sugarbeet against early germinating waterhemp until the chloroacetamides are applied. However, we have wondered about waterhemp control from less than labeled rates. That is, are less than labeled rates providing full control for a short duration or are less than labeled rates providing substandard control for short duration?

Waterhemp control was dependent on ethofumesate PRE rate and evaluation timing (Figure 2). We believe our target must be 85% to 90% waterhemp control for 30 to 40 days or until chloroactamide herbicides can be applied and are activated by rainfall. The 85% waterhemp control threshold was accomplished when ethofumesate was applied at 4.5, 6.0, or 7.5 pt/A. The 90% waterhemp control threshold was accomplished when ethofumesate was applied at 6.0 or 7.5 pt/A. Ethofumsate PRE at 7.5 pt/A provided 85% waterhemp control, 54 days after application, indicating ethofumesate at the full rate does not provide season long waterhemp control. Sub-lethal rates or ethofumesate at 1.5 or 3.0 pt/A did not meet our 85% to 90% waterhemp control threshold. These data suggest sub-lethal rates are providing insufficient waterhemp control, even for a short duration.

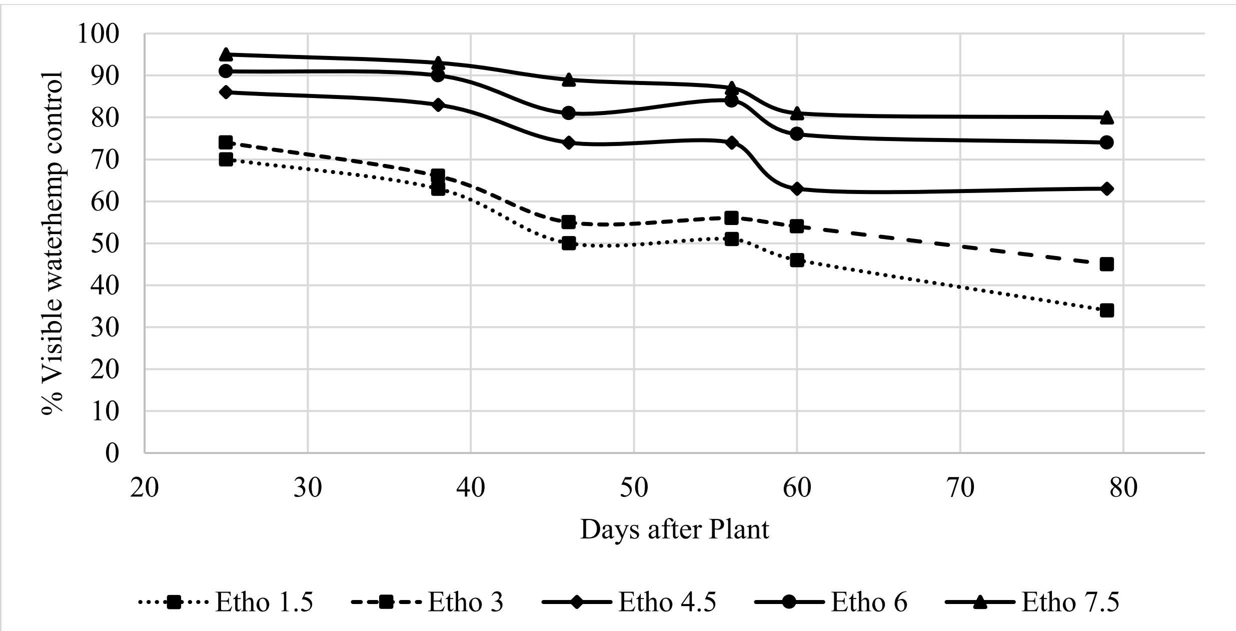

Figure 2. Waterhemp control from ethofumesate PRE across rates, Blomkest, MN, 2020.

We continued to evaluate the fate of ethofumesate on both nurse crops and waterhemp control (Peters et al. 2022). Our results suggest ethofumesate rate alone does not overcome environmental challenges when timely, adequate, and penetrating rainfall fails to occur. Thus, mixing Dual Magnum with ethofumesate is a strategy to reduce risk, as Dual Magnum adsorbs less to soil and is more water soluble, providing short duration control until sufficient rainfall occurs for ethofumesate activation. Incorporating ethofumesate is a risk-aversion strategy, provided ethofumesate is incorporated 0.5- or 1-inch (tillage at 1-inch or 2-inch) with tillage equipment that enables movement of ethofumesate into the soil, thereby maximizing pigweed control.

The objective of this 2023 experiment was to 1) demonstrate crop safety to nurse crop spring barley and 2) determine the duration of waterhemp control from ethofumesate.

Materials and Methods

An experiment was conducted near Moorhead, MN in 2023. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 24 at Moorhead, MN in 2023. Sugarbeet was seeded in 22-inch rows at approximately 62,000 seeds per acre with 4.5 inch spacing between seeds. Herbicide treatments are found in Table 2.

Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Spring barley was seeded perpendicular to sugarbeet rows using a Land Pride grain drill (Great Plains Manufacturing, Salina, KS). Ethofumesate applied preplant and spring barley was incorporated into soil parallel to sugarbeet rows using a

Kongskilde s-tine field cultivator with rolling baskets set approximately 2-inch deep and operated at approximately 5 mph.

Table 2. Herbicide treatment, application timing, and rate, Moorhead, MN, 2023.

Herbicide Treatment	Application timing	Rate (pt/A)
Ethofumesate	Preplant	2
Ethofumesate	Preplant	4
Ethofumesate	Preplant	6
Ethofumesate	Preplant	8
Ethofumesate	Preplant	10
Ethofumesate	Preplant	12
Ethofumesate	Preemergence	2
Ethofumesate	Preemergence	4
Ethofumesate	Preemergence	6
Ethofumesate	Preemergence	8
Ethofumesate	Preemergence	10
Ethofumesate	Preemergence	12

Spring barley nurse crop ground coverage was evaluated using a numeric scale of 1 to 9 (1-3=poor ground coverage, 4-6=good ground coverage, and 7-9=excellent ground coverage). Visible waterhemp control (0 to 100% control, 0% indicating no control, and 100% indicating complete control) was collected 34, 42, 49, 54, and 67 days after treatment (DAT). Experimental design was randomized complete block design with four replications in a factorial arrangement, with factors being herbicide application method and herbicide rate. Data were analyzed with the ANOVA procedure of ARM, version 2023.6 software package.

Results and Discussion

Herbicide activation technique did not interact with ethofumesate rate (P-value=0.3202, 0.6570, 0.8676; 13, 19, 26 days after planting (DAP), respectively) so assessment of ground coverage was averaged across activation technique. However, we observed improved spring barley ground coverage across rates when ethofumesate was applied PRE as compared with ethofumesate machine incorporated into soil (data not shown). The site received 0.8-inch rainfall, 5 and 7 DAP, which should have been plenty of rainfall to both activate ethofumesate PRE into the soil and further distribute ethofumesate incorporated with tillage.

Spring barley stands decreased as ethofumesate rate increased (Figure 3). We observed what was considered 'poor nurse crop ground cover' following ethofumesate at 12 pt/A. We observed 'good nurse crop ground coverage' following ethofumesate rates of 4 to10 pt/A and 'excellent nurse crop ground coverage' following ethofumesate at 2 pt/A. These evaluations were consistent between 12 and 25 DAP; however, we observed numerically improved spring barley ground coverage over time. This could be due to continued growth and tillering as the spring barley established.

Ultimately, what is considered acceptable nurse crop ground cover is up to the producer. Our experiment indicates ethofumesate applied for waterhemp control at greater than 2 pt/A significantly reduced nurse crop ground coverage.

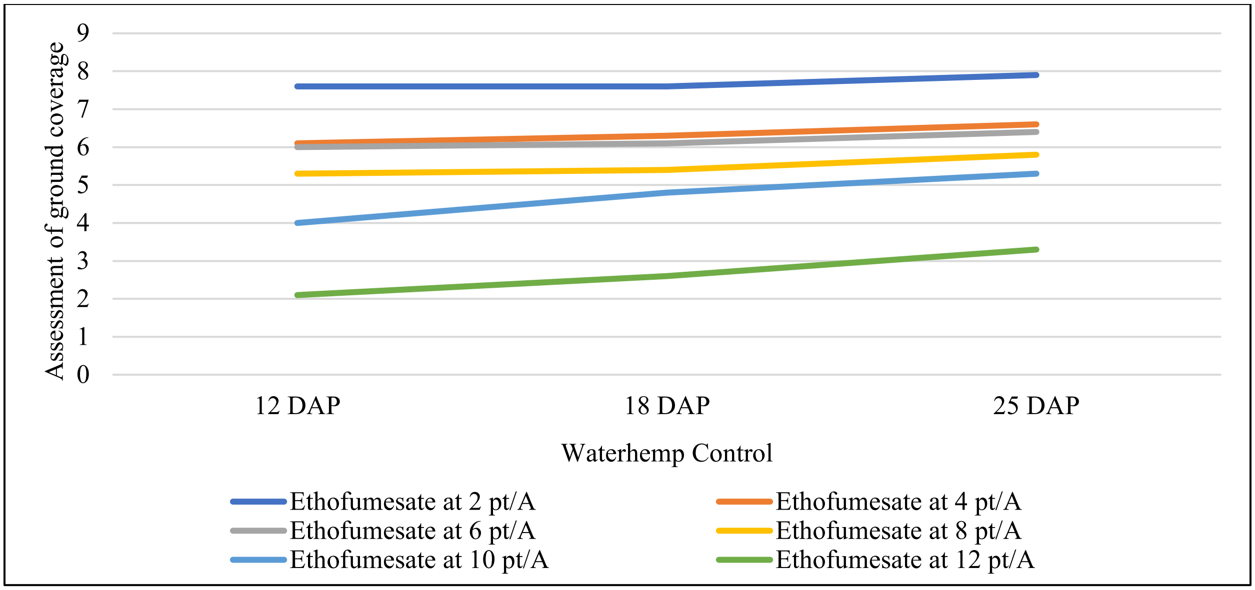

Figure 3. Spring barley ground coverage 12, 18, and 25 days after planting (DAP) in response to ethofumesate rate, Moorhead, MN, 2023.

Herbicide activation technique did not interact with ethofumesate rate (P-value >0.10) 34 to 67 DAP so assessment of waterhemp control was averaged across herbicide application method. Overall, waterhemp control was slightly greater when ethofumesate was rainfall activated as compared with tillage incorporation (Table 3). Improved waterhemp control PRE ranged from 14% to 20% across evaluation timing. Depth of incorporation for preplant incorporated (PPI) treatments may have contributed to decreased waterhemp control as compared with PRE treatments. We have often cautioned producers on pushing ethofumesate too deep into the soil with tillage since waterhemp germinates from the surface to 1-inch deep in soil. Ethofumesate PRE provided greater and longer lasting control as compared with ethofumesate PPI, which is likely due to the uniformity and consistency from rainfall activation.

Table 3. Waterhemp control in response to herbicide application method, averaged across ethofumesate rate, Moorhead, MN, 2023.[a]

	Waterhemp Control				
Herbicide Application Method	34 DAP[b]	42 DAP	49 DAP	54 DAP	67 DAP
	------------	------------	----%----	------------	------------
Preplant Incorporated	63 b	54 b	47 b	47 b	31 b
Preemergence	77 a	74 a	61 a	64 a	54 a
LSD (0.10)	6	6	7	6	8

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b] DAP=days after planting.

Waterhemp control and length of waterhemp control was dependent on rate (Table 4). Ethofumesate at 10 and 12 pt/A provided the greatest waterhemp control across all evaluation timings. However, ethofumesate at 10 and 12 pt/A are not labeled rates in sugarbeet. Ethofumesate at 4 to 8 pt/A provided similar waterhemp control up to 34 days after planting. Waterhemp control from ethofumesate at 6 and 8 pt/A was the same up to 67 days after application (DAA). Ethofumesate at 4 pt/A provided greater waterhemp control across evaluation timings in this experiment.

Table 4. Waterhemp control in response to ethofumesate rate, averaged across activation technique, Moorhead, MN, 2023.[a]

		Waterhemp Control				
Herbicide Treatment	Rate	34 DAP[b]	42 DAP	49 DAP	54 DAP	67 DAP
	---pt/A---	---------------------------------------%---------------------------------------				
Ethofumesate	2	45 c	32 d	15 e	19 d	10 e
Ethofumesate	4	66 b	54 c	34 d	38 c	29 d
Ethofumesate	6	70 b	72 ab	64 bc	61 b	49 bc
Ethofumesate	8	74 ab	66 bc	58 c	62 b	41 cd
Ethofumesate	10	82 a	77 ab	75 ab	74 a	59 ab
Ethofumesate	12	84 a	83 a	78 a	77 a	66 a
LSD (0.10)		10	11	11	11	13

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b] DAP=days after planting.

Conclusions
Spring barley ground cover decreased as ethofumesate rate increased from 2 to 12 pt/A and loss of ground cover was greater from ethofumesate PPI than ethofumesate PRE. Ethofumesate at 2 pt/A caused negligible loss of ground cover; however, ethofumesate rates between 4 and 6 pt/A may cause up to 50% loss of nurse crop ground cover. Ground cover from nurse crops is a grower preference. Ultimately, the effect of ethofumesate rate and application method on cover crop will be dependent on conditions after application method and once herbicide rate is selected. Waterhemp control from ethofumesate was greatest PRE, indicating ethofumesate dilution occurs with mechanical tillage incorporation. Loss of control from mechanical activation as compared with rainfall activation averaged 18% across evaluation timings at Moorhead, MN in 2023. This outcome was in a season when there was timely rainfall for activation after application. Ultimately, the decision is about waterhemp control and a compromise between nurse crop ground cover and expectations for early season waterhemp control. Ethofumesate at 2 pt/A alone PRE does not accomplish early season waterhemp control and is discouraged (Figure 4). We encourage ethofumesate alone at 4 to 6 pt/A PRE or ethofumesate at 2 to 3 pt/A tank mixed with Dual Magnum PRE at 0.5 to 0.75 pt/A, targeting a minimum of 85% waterhemp control for 30 to 40 days or until chloroacetamide POST application.

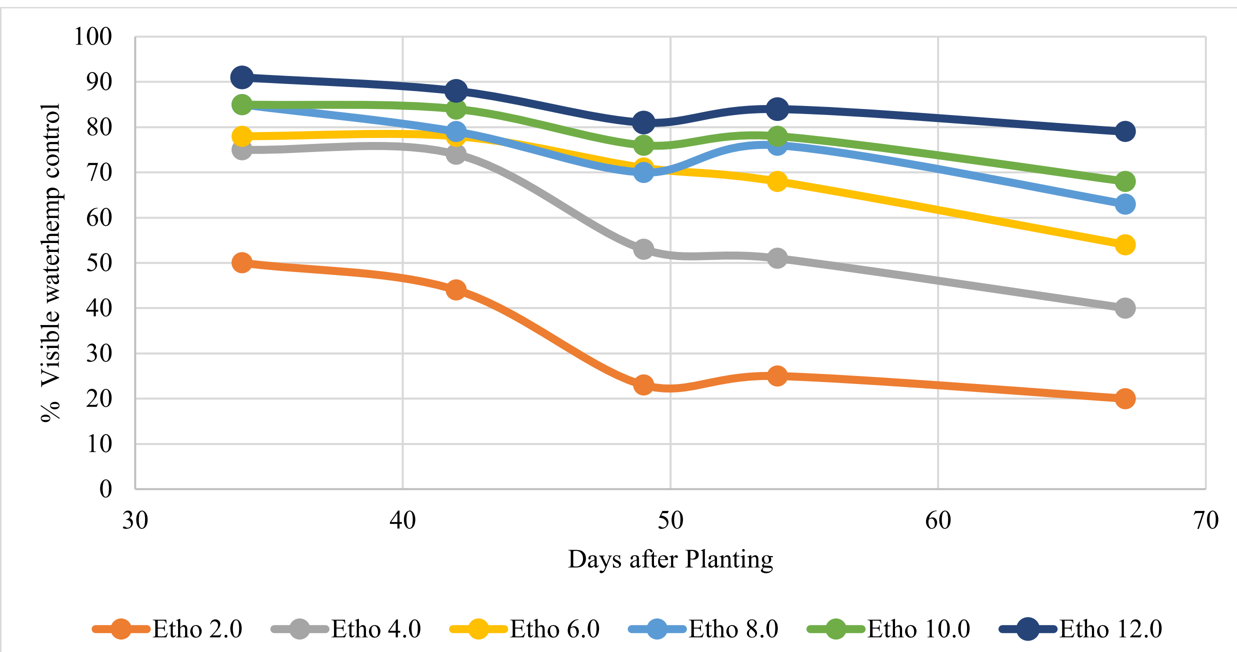

Figure 4. Waterhemp control from ethofumesate PRE across rates, Moorhead, MN, 2023.

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WATERHEMP CONTROL FROM SOIL RESIDUAL PREEMERGENCE AND POSTEMERGENCE HERBICIDES, CONTINUED IN 2023

Thomas J. Peters[1] and Alexa L. Lystad[2]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, and [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND

Summary
1. Outlook applied early postemergence reduced sugarbeet final stand.
2. PRE followed by split layby program improved waterhemp control as compared with the split layby program alone.

Introduction
Peters et al. (2023) concluded rainfall is critical for activating soil residual herbicides and achieving satisfactory waterhemp control from soil residual herbicides in previous reports. This research reinforces that a strategy to layer soil residual herbicides, starting at planting and after sugarbeet has emerged, is our best program for controlling waterhemp in sugarbeet. Finally, this research demonstrated excellent sugarbeet safety from the chloroacetamide herbicides. We have consistently stated the three chloroacetamide active ingredients commercially available in sugarbeet, Outlook, *S*-metolachlor products and Warrant, are equally effective at providing waterhemp control, and that the differences in waterhemp control among chloroacetamide products are minor. A continuation of this work was conducted in 2023. We wanted to incorporate our waterhemp control practices from the mid- to southern Red River Valley to the Northern Red River Valley.

Objective
The objective of this experiment was to demonstrate a weed control system for waterhemp control in sugarbeet in the Northern Red River Valley.

Materials and Methods
An experiment was conducted near Drayton, ND in 2023. Treatments are listed in Table 1. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 13, seeded in 22-inch rows at a population and seed spacing commercially accepted by sugarbeet growers in the Red River Valley. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through XR8002 flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

Table 1. Herbicide treatment, rate, and application timing, Drayton, ND, 2023.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (fl oz/A)	Sugarbeet stage (lvs)
No	PowerMax3 + etho / Ultra Blazer[b]	25 + 6 / 16	2 / 6-8
No	Outlook / Outlook	12 / 12	2 / 6-8
No	Dual Magnum / Dual Magnum	17.6 / 17.6	2 / 6-8
No	Dual Magnum / Outlook	17.6 / 12	2 / 6-8
Yes[c]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	PRE/ 2 / 6-8
Yes	Outlook / Outlook	12 / 12	PRE/ 2 / 6-8
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	PRE/ 2 / 6-8
Yes	Dual Magnum / Outlook	17.6 / 12	PRE/ 2 / 6-8

[a]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with POST applications not containing Ultra Blazer.
[b]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[c]Ethofumesate + Dual Magnum at 2.0+0.5 pt/A PRE.

Visible sugarbeet growth reduction injury was evaluated using a 0 to 100% scale (with 0% representing no visible injury and 100% as complete loss of plant / stand) approximately 14 and 21 days (+/- 3 days) following the 6-8 leaf application. Sugarbeet stand was measure by counting the number of sugarbeet in a 10 ft row in rows three and four of a six-row plot. Stand counts were collected June 14 or the same day as visible sugarbeet assessment. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) and was collected 30, 51, and 66 days after planting. Experimental design was randomized complete block with four replications in a factorial treatment arrangement, factors being use of PRE herbicide (no/yes) and POST herbicide treatments. Data were analyzed with the ANOVA procedure of ARM, version 2023.5 software package.

Results and Discussion

The experiment at Drayton, ND was planted to "dry" seedbed moisture. After planting, the site received 0.25-inch of rain over 12 days after planting (DAP) (Table 2). Rain events that followed both planting and herbicide applications were sporadic with low accumulation. As a result, sugarbeet stands were variable at this location. We elected to apply herbicide POST treatments prior to full sugarbeet stands since activating rainfall was sparse. Our logic was we would need a second rain event to activate soil residual herbicides if we waited for the initial rain event to enable completion of final stand. Further, this application timing also allowed us to evaluate how soil residual herbicides affect sugarbeet germination and stand.

Table 2. Herbicide application dates, sugarbeet growth stage and cumulative rainfall the first 10 days following herbicide application, Drayton, ND, 2023.

	Drayton, ND[a]		
Herbicide Treatment	**Herbicide Application Dates**	**Sugarbeet Growth Stage**	**Rainfall**
		--lvs--	--inch--
PRE Application	May 15	PRE	0.25
EPOST Application	May 31	2-4	0.49
POST Application	June 15	6-8	4.83[b]
		Total:	**5.57**

[a]Precipitation data collected from nearby weather stations operated by North Dakota Agricultural Weather Network (NDAWN).
[b]Rainfall amount of 4.53" reported on the 10th day following POST application.

Sugarbeet stand ranged from 80 to144 plants per 100-feet of row across plots, reflecting the dry conditions (Table 3). There was no significant sugarbeet stand differences from PRE or no PRE (125 vs.126 sugarbeet per 100-ft, no PRE vs. PRE, averaged across POST treatment). However, Outlook followed by Outlook POST significantly reduced stand or tended to reduce stand as compared with the other POST treatments, following no PRE and PRE treatments, respectively.

Sugarbeet injury ranged from 0% to 20%, 14 days after application B (DAAB) and 0% to 53%, 20 days after application C (DAAC) (Table 3). Injury assessment might have been influenced by stand challenges. However, the greatest sugarbeet injury observed was bronzing phenotype and growth reduction from applications with Ultra Blazer, with or without a PRE applied. Sugarbeet injury tended to increase POST treatments following a PRE; however, was not significantly different compared with no PRE. POST treatments with Outlook followed by Outlook resulted in sugarbeet injury statistically comparable to treatments with Ultra Blazer POST.

Table 3. Sugarbeet stand and visible injury in response to PRE and POST treatment, Drayton, ND, 2023.[a]

Herbicide Treatment PRE	Residual Herbicide Treatment POST[b]	Rate	Sugarbeet Stand	Sugarbeet Injury	
				14 DAAB[c]	20 DAAC
		----fl oz/A----	--per 100 ft--	---------%---------	
No	PowerMax3 + etho / Ultra Blazer[d]	25 + 6 / 16	135 a	0 a	38 bc
No	Outlook / Outlook	12 / 12	80 b	3 a	22 ab
No	Dual Magnum / Dual Magnum	17.6 / 17.6	140 a	4 a	0 a
No	Dual Magnum / Outlook	17.6 / 12	143 a	5 a	8 a
Yes[e]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	144 a	0 a	53 c
Yes	Outlook / Outlook	12 / 12	100 ab	20 b	40 bc
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	123 ab	0 a	18 ab
Yes	Dual Magnum / Outlook	17.6 / 12	135 a	5 a	0 a
LSD (0.10)			**44**	**10**	**25**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with POST application not containing Ultra Blazer.
[c]DAAB = Days after application B; DAAC = Days after application C.
[d]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[e]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE.

Sugarbeet growers and agriculturalist frequently ask about applying Outlook mixed with glyphosate and ethofumesate when the majority of sugarbeet in field have reached the 2-lf stage, but when sugarbeet have not reached a full stand. In most situations, a rain event is in the weather forecast and the producer wants to "hook a rain." My reply is: "Are you satisfied with current stand in field, not knowing the fate of sugarbeet following Outlook application?" Outlook sprayed on the soil surface and not rainfall activated will not affect sugarbeet left to emerge. However, the fate of sugarbeet in the event that an activating rain occurred following Outlook application was not known. These data suggest that Outlook does affect sugarbeet germination and emergence. In contrast, *S*-metoachlor products have greater sugarbeet tolerance which is the reason why Dual Magnum is approved for use preemergence using the 24(c) local needs label in Minnesota and North Dakota.

Waterhemp control ranged from 85% to 99%, 14 DAAB and 87% to 97%, 20 DAAC (Table 4). Treatments with Outlook alone, Dual Magnum alone, or Dual Magnum followed by Outlook controlled waterhemp, even in a dry year. We did not observe waterhemp control differences between layby treatments. This could be contributed to the lack of rain following planting (Table 2).

Table 4. Waterhemp control in response to PRE and POST treatment, Drayton, ND, 2023.[a]

Herbicide Treatment PRE	Residual Herbicide Treatment POST[b]	Rate	Waterhemp Control	
			14 DAAB[c]	20 DAAC
		----fl oz/A----	-------------%------------	
No	PowerMax3 + etho / Ultra Blazer[c]	25 + 6 / 16	85 b	88 ab
No	Outlook / Outlook	12 / 12	95 ab	96 ab
No	Dual Magnum / Dual Magnum	17.6 / 17.6	93 ab	87 b
No	Dual Magnum / Outlook	17.6 / 12	96 a	94 ab
Yes[e]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	98 a	95 ab
Yes	Outlook / Outlook	12 / 12	98 a	97 a
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	99 a	97 a
Yes	Dual Magnum / Outlook	17.6 / 12	99 a	94 ab
LSD (0.10)			**10**	**9**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied POST application not containing Ultra Blazer.
[c]DAAB = Days after application B; DAAC = Days after application C.
[d]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[e]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE.

We observed a significant increase in waterhemp control when a PRE was applied as compared with no PRE (Table 4). This has been a common observation in the southern Red River Valley, especially in years with May sugarbeet plantings. However, this experiment echoed our historical results that a PRE followed by the split layby program will provide increased waterhemp control across the Red River Valley as a whole, even in a dry year, as compared to the split layby program, alone.

Conclusion

There was a very high amount of variability across the experiment due to lack of rain; however, we did continue to observe that the best weed control strategy for waterhemp is layered soil residual herbicides, starting with a PRE followed by split layby application. The three chloroacetamide herbicides available in sugarbeet are equally effective at providing waterhemp control. We observed dry conditions creating open furrow with exposed sugarbeet seed, well past planting date, which provides difficulty in quantifying whether stand loss was due to lack of rainfall or herbicide application. We would like to further investigate the results from Outlook followed by Outlook and strengthen the findings of the impact it had on sugarbeet stand.

Acknowledgement

We wish to thank Steve and Julie Helm, Drayton, ND, for their collaboration with field research in 2023.

References

Peters TJ, Lystad AL and Mettler D (2023) Waterhemp control from soil residual, pre-emergence, and post-emergence herbicides in 2022. Sugarbeet Res Ext Rep. 53: 12-17

SUMMARY OF ULTRA BLAZER APPLIED IN SUGARBEET

Thomas J. Peters[1], Alexa L. Lystad[2], Emma Burt[3], and David C. Mettler[4]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [3]Research Agronomist, Minn-Dak Farmers' Cooperative, Wahpeton, ND, and [4]Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary

1. Environmental conditions at application and adjuvants influence sugarbeet tolerance and waterhemp control from Ultra Blazer.
2. Glyphosate (Roundup PowerMax/Roundup PowerMax3) mixed with Ultra Blazer consistently has improved waterhemp control from Ultra Blazer.
3. Roundup PowerMax3 mixed with Ultra Blazer increased necrosis and sugarbeet growth reduction injury and reduced root yield and recoverable sucrose as compared with Ultra Blazer alone.
4. Nozzle selection and 20 gpa spray volume improved waterhemp control, theoretically, by improving coverage.
5. Control escape waterhemp less than 4-inches tall with Ultra Blazer at 16 fl oz/A with NIS; control 'train-wreck' situations with Roundup PowerMax3 mixed with Ultra Blazer and AMS.

Introduction

I remember asking Dr. Dexter, Professor Emeritus and retired Extension Sugarbeet and Weed Control Specialist from 1969 to 2007, if he had any regrets; ideas he never got around to pursuing. Alan immediately replied that he wished he would have spent more time investigating Ultra Blazer in sugarbeet. I took that hint and invested seven years pursuing use of Ultra Blazer in sugarbeet. This will be our final report.

The first experiments were proof of concept; exploring sugarbeet injury from Ultra Blazer. We found that environment was important. Ultra Blazer was more active during hot and humid environments as compared with cooler or drier air. However, we learned that we could avoid the effects of environment by applying Ultra Blazer to sugarbeet greater than the 6-lf stage. Ms. Emma Burt's Master of Science thesis work focused on Ultra Blazer alone and with adjuvants and Ultra Blazer mixed with Roundup PowerMax and/or Stinger. We found that petroleum or vegetable oil-based adjuvants increased sugarbeet injury and waterhemp control. Sugarbeet injury was greater when Ultra Blazer was mixed with HSMOC (high surfactant methylated seed oil), MSO (methylated oil concentrate), or COC (crop oil concentrate) than with NIS (non-ionic surfactant). We also found sugarbeet injury from Ultra Blazer mixed with Roundup PowerMax was greater than from either Ultra Blazer or Roundup PowerMax alone. Sugarbeet injury was attributed to the formulated surfactant with glyphosate, not the salt of glyphosate. Further, adding Ultra Blazer with glyphosate and either *S*-metolachlor or Outlook, applied at the 6- to 8-lf sugarbeet stage in the layby program application, caused unacceptable injury. Finally, our original experiments were Ultra Blazer tank mixed with Roundup PowerMax. We believe Roundup PowerMax3 mixed with Ultra Blazer causes more sugarbeet injury than the Roundup PowerMax formulation mixed with Ultra Blazer.

Ultra Blazer was applied to approximately 80,000 acres in 2021 and 2022 to control escape waterhemp. The primary concern from producers was regrowth to waterhemp, especially when sugarbeet leaves partially covered waterhemp. Experiments in 2022 and 2023 were designed to improve waterhemp control by increasing either carrier volume or through nozzle selection to improve spray coverage. Second, in an effort to find the appropriate balance between efficacy and tolerance, we evaluated applying Ultra Blazer at 12 fl oz/A in a split application, Ultra Blazer at 16 fl oz/A with COC, or mixing Ultra Blazer plus Roundup PowerMax3 with Warrant as a safener. This report summarizes sugarbeet tolerance and waterhemp control experiments conducted in 2022 and 2023.

Materials and Methods

Sugarbeet tolerance experiments were conducted near Crookston, Hendrum, Kent, Lake Lillian, and Murdock, MN in 2023. Waterhemp efficacy experiments were conducted near Moorhead and Blomkest, MN. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at about 62,000 seeds per acre with 4.6 inch spacing between seeds. We had started the Moorhead experiment in a sugarbeet area; however, due to challenges with waterhemp emergence and sugarbeet size, we moved the Moorhead experiment into a bulk fill soybean area to be consistent with waterhemp size at application.

Treatments shown in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 2 and 3.

Table 1. Herbicide treatment, herbicide rate, and application timing across locations in 2023.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	6-8 lf
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	6-8 lf / A + 3-days
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	2 lf / 6 lf

Table 2. Application information for tolerance experiments.

	Crookston	Hendrum	Kent	Murdock	Lake Lillian
Plant Date	May 5	May 16	May 17	May 9	May 4
Application Date	June 8	June 15	June 21	June 9	June 6
Time of Day	10:30 AM	10:00 AM	6:00 PM	12:30 PM	8:00 AM
Air Temperature (F)	72	73	86	73	61
Relative Humidity (%)	56	62	43	57	83
Wind Velocity (mph)	8	3	8	7	6
Wind Direction	SSE	NE	NW	SW	E
Soil Temp. (F at 6”)	70	66	-	-	-
Soil Moisture	Good	Fair	-	-	-
Cloud Cover (%)	50	100	-	-	-

Table 3. Application information for efficacy experiments.

	Moorhead	Blomkest
Plant Date	May 24	May 22
Application Date	July 5	June 23
Time of Day	7:00 AM	7:00 AM
Air Temperature (F)	67	66
Relative Humidity (%)	43	94
Wind Velocity (mph)	2	2
Wind Direction	-	-
Soil Temp. (F at 6”)	70	70
Soil Moisture	Good	-
Cloud Cover (%)	90	20

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated approximately 7 and 14 days after treatment (DAT) as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Visible weed control was evaluated 7, 14, and 21 days after the 2-lf stage application using a 0 to 100 scale (0 is no control and 100 is complete control). All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip.

At harvest for tolerance experiments, sugarbeet was defoliated, harvested mechanically from the center two rows of each plot, and weighed. A root sample (about 20 lbs) was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Experimental design was randomized complete block with six replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Results

Tolerance and Yield Components. Sugarbeet necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application. All Ultra Blazer treatments caused necrosis injury; however, necrosis injury was greatest from Ultra Blazer at 16 fl oz/A plus crop oil concentrate (COC) at 1.25% v/v and was consistent across locations (Table 4). Similarly, an application of Roundup PowerMax3 mixed with Ultra Blazer plus AMS increased necrosis injury as compared with Ultra Blazer alone. Repeat Ultra Blazer applications of 12 fl oz/A followed by (fb) 12 fl oz/A gave slightly less necrosis injury than Ultra Blazer at 16 fl oz/A; however, the repeat Ultra Blazer application extended the duration of necrosis injury as compared with a single application.

Table 4. Sugarbeet visible injury from herbicide treatments, across locations, 2023.[a]

		Necrosis[b]	Sugarbeet Growth Reduction		
Herbicide Treatment	**Rate**	**3 DAAC[c]**	**3 DAAC**	**10 DAAC**	**20 DAAC**
	-----fl oz/A-----	----------------------------------%			--------------------------------
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	26 bc	25 b	22 b	13 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	21 b	22 b	33 bc	23 bc
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	49 d	43 c	46 d	34 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	48 d	44 c	43 cd	32 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	35 c	29 b	28 b	18 b
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	1 a	4 a	2 a	3 a
P-Value (0.05)		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Nec. = Visual necrosis.
[c]DAAC = Days after application C.

Necrosis injury from Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS was less than injury from Ultra Blazer plus Roundup PowerMax3 and liquid AMS (Table 4). Sugarbeet necrosis and growth reduction injury from adding Warrant to Ultra Blazer and Roundup PowerMax3 was similar to the Ultra Blazer at 16 fl oz/A plus NIS standard treatment, across locations.

Sugarbeet growth reduction injury across treatments averaged 28%, 29%, and 21%, 3, 10, and 20 DAAC, respectively (Table 4). As with necrosis, growth reduction injury was greatest when COC or Roundup PowerMax3 with liquid AMS was mixed with Ultra Blazer. Sugarbeet growth reduction injury from Ultra Blazer at 16 fl oz/A with NIS was similar to sugarbeet injury from 2-times Roundup PowerMax3 applications with NIS and liquid AMS. Two-times Ultra Blazer application at 12 fl oz/A with NIS gave growth reduction injury similar to Ultra Blazer at 16 fl oz/A with NIS; however, injury was greater than injury from the Roundup PowerMax3 control.

Root yield, % sucrose, and recoverable sucrose from Ultra Blazer at 16 fl oz/A plus NIS were the same as two applications of glyphosate alone (Table 5). Root yield and % sucrose from two applications of Ultra Blazer at 12 fl oz/A with NIS were the same as Ultra Blazer at 16 fl oz/A. However, recoverable sucrose from two applications of Ultra Blazer applications at 12 fl oz/A was less than a single application of Ultra Blazer at 16 fl oz/A.

Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS appeared to reduce sugarbeet vegetative injury and yield components as compared with Ultra Blazer mixed with Roundup PowerMax3 and liquid AMS. This is consistent from results in Michigan (personal communication with Dr. Christy Sprague).

Table 5. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across locations, 2023.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	-----fl oz/A-----	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	35.5 ab	17.7	11,180 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	34.2 bc	17.7	10,611 c
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	33.3 c	17.7	10,417 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	33.3 c	17.8	10,430 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	34.9 bc	17.5	10,737 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	37 a	17.8	11,639 a
P-Value (0.05)		**0.001**	**NS**	**0.001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.

<u>Waterhemp Control.</u> The waterhemp control experiment at Moorhead was terminated and reestablished in soybean. The efficacy experiment was in sugarbeet at Blomkest. Thus, we elected to consider each experiment singly due to the difference in crop species between the two experiments.

Waterhemp control ranged from 40 to 88% at Moorhead, MN and 68 to 93% at Blomkest, MN, 14 DAAC (Table 6). Waterhemp control was or tended to be best when Ultra Blazer was tank mixed with Roundup PowerMax3 plus AMS across locations and evaluations. These results are consistent with results from Ms. Emma Burt's Master of Science research and other results previously communicated. Ultra Blazer plus COC provided or tended to provide waterhemp control similar to Ultra Blazer mixed with Roundup PowerMax3 across locations and evaluations. Two applications of Ultra Blazer at 12 fl oz/A gave better waterhemp control at Blomkest than Moorhead. Conversely, Ultra Blazer plus Roundup PowerMax3 and Warrant plus AMS gave better control at Moorhead than Blomkest.

Table 6. Waterhemp control 7 and 14 days after herbicide treatments, two locations, 2023.[a]

		Waterhemp Control			
		Moorhead		**Blomkest**	
Herbicide Treatment	**Rate**	**7 DAAC[b]**	**14 DAAC**	**7 DAAC**	**14 DAAC**
	-----fl oz/A-----	---%			---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	71 b	61 c	79 abc	81 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	74 b	71 c	84 ab	89 ab
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	83 ab	73 bc	88 ab	81 abc
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	91 a	85 ab	93 a	93 a
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	89 a	88 a	75 bc	73 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	43 c	40 d	69 c	68 c
P-Value (0.05)		**<0.0001**	**<0.0001**	**0.0383**	**0.0472**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

A repeat application of Ultra Blazer at 12 fl oz/A plus NIS gave waterhemp control similar to a single Ultra Blazer application at 16 fl oz/A plus NIS.

Roundup PowerMax3 provided excellent common lambsquarters control whereas Ultra Blazer provided little or no common lambsquarters control (Table 7). We did not observe any antagonism with common lambsquarters when Ultra Blazer and Warrant were tank mixed with glyphosate.

Table 7. Common lambsquarters control 7 and 14 days after herbicide treatments, Moorhead, MN, 2023.[a]

		Common Lambsquarters Control	
Herbicide Treatment	**Rate**	**7 DAAC[b]**	**14 DAAC**
	-----fl oz/A-----	-------------------------%-----------------------	
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	3 d	0 e
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	35 b	10 d
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	23 c	23 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	99 a	94 b
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	99 a	97 ab
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	98 a	98 a
P-Value (0.05)		**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Conclusion
The 2023 (and 2022) Ultra Blazer experiments were designed to determine if sugarbeet injury in response to Ultra Blazer could be reduced, while maintaining or improving waterhemp control through improved water volume, spray nozzle selection, adjuvants or herbicide mixtures. Unfortunately, there is no 'silver bullet' with Ultra Blazer. COC mixed with Ultra Blazer increased vegetative sugarbeet injury and reduced root yield while providing only a modest improvement in waterehemp control. Repeat Ultra Blazer applications extended the length of time with visual necrosis with only a modest improvement in waterhemp control. Mixing Warrant with Ultra Blazer, Roundup PowerMax3, and AMS reduced sugarbeet injury but waterhemp control was inconsistent across locations. We have not investigated glyphosate formulations with adjuvants different from Roundup PowerMax3. Once again, improving sugarbeet safety likely results in less waterhemp control. At this time, I am hesitant to recommend Warrant mixtures with Ultra Blazer and Roundup PowerMax3. Warrant, a chloroacetamide herbicide, is a very important component to our waterhemp control strategy. Suggesting Warrant can be used to safen sugarbeet injury from Ultra Blazer and Roundup PowerMax3 seems to send a confusing message. Likewise, the weed control results from Warrant mixtures with Ultra Blazer and Roundup PowerMax3 were inconsistent.

We recommend applying single Ultra Blazer applications at 16 fl oz/A plus NIS for waterhemp control with XR TeeJet, Turbo TeeJet, or Turbo TwinJet nozzles in 20 gpa water carrier (Table 8). Waterhemp should be less than 4-inches tall to optimize control. Ultra Blazer mixtures with Roundup PowerMax3 may be used in situations with significant waterhemp control challenges. We recommend ammonium sulfate with Roundup PowerMax3 and Ultra Blazer but no additional surfactant. As with Ultra Blazer alone, optimize spray quality to deliver good spray coverage.

Table 8. Sugarbeet necrosis, growth reduction, and waterhemp control in response to spray nozzle and water carrier volume, Moorhead, MN, 2022.

Spray Nozzle[a]	Necrosis[b]		Growth Reduction[b]		Waterhemp Control[c]	
	15 GPA	20 GPA	15 GPA	20 GPA	15 GPA	20 GPA
XR TeeJet	33 abc	38 ab	19 a	20 a	60 c	80 a
AIXR	23 c	23 c	8 c	8 c	64 c	68 c
Turbo TeeJet	28 bc	30 bc	15 ab	13 bc	69 bc	78 ab
Turbo TwinJet	26 c	43 a	10 bc	19 a	83 a	81 a
P-Value (0.20)	0.1781		0.0324		0.0357	

[a]TeeJet.
[b]Necrosis and growth reduction, 13 DAT.
[c]Waterhemp control, 41 DAT.

TOLERANCE AND WEED CONTROL FROM SPIN-AID IN SUGARBEET IN 2023

Thomas J. Peters[1], Alexa L. Lystad[2], and [3]Adam Aberle

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist, and [3]Research Technician
North Dakota State University & University of Minnesota, Fargo, ND and North Dakota State University

Summary

1. No sugarbeet vegetative injury or yield component differences were observed across hybrids representing diverse sugarbeet genetics.
2. A single Spin-Aid application will not control kochia or common ragweed.
3. Apply ethofumesate PRE before Spin-Aid applications, especially for kochia control.
4. Time Spin-Aid applications according to weed size, rather than sugarbeet size. Spin-Aid at 16 fl oz/A plus ethofumesate on cotyledon to 2-lf sugarbeet followed by 24-32 fl oz/A Spin-Aid plus ethofumesate on 4- to 6-lf sugarbeet.

Introduction

Glyphosate resistant (GR) kochia is reemerging as an important weed management challenge in the Red River Valley and is spreading into west central Minnesota (Peters et al. 2022). We advise producers to grow crops (and select herbicides) that control kochia in the rotation since kochia seed is viable for up to two years (Dille et al. 2017). Wheat commonly grown before sugarbeet in the Red River Valley is competitive with kochia and enables use of herbicides enabling effective kochia control. However, adapting kochia biotypes and delayed spring planting has made kochia control challenging.

Growers lack effective herbicide options to control GR kochia in sugarbeet. Phenmedipham was registered in 1970 and sold under the trade name 'Betanal' from 1970 through 1981. Phenmedipham selectively controls small kochia by moving acropetally to the edges of leaves. Phenmedipham effectively controls kochia when applied in direct sunlight and when air temperatures are 70 F or greater.

Belchim Crop Protection USA markets phenmedipham using the trade name 'Spin-Aid' for control of broadleaf weeds POST on spinach and recently completed the acquisition of the sugarbeet registration from Bayer Crop Science. Belchim Crop Protection secured a 24 (c) local needs registration for Spin-Aid which provided Minnesota and North Dakota sugarbeet growers with a postemergence herbicide option for kochia and common lambsquarters control before the 2023 growing season.

Field and greenhouse experiments were conducted to determine how to best integrate Spin-Aid into a weed control program (Peters et al. 2023). Two-times Spin-Aid applications up to 32 fl oz/A partially controlled kochia less than 1-inch tall (Figure 1). Further, Spin-Aid use rate was determined by sugarbeet growth stage at timing of application. Finally, mixing Spin-Aid with ethofumesate seemed to improve kochia control as compared with Spin-Aid alone.

We learned from growers and academicians with previous experience with phenmedipham in sugarbeet. Betanal historically was applied as a single application or 2-times applications at up to 96 fl oz/A for kochia control. Sugarabeet injury was variety dependent and increased when ethofumesate was applied preemergence ahead of Betanal. The label and previous experience indicated improved control of common lambsquarters under moisture stress from Roundup PowerMax mixed with phenmedipham. The label also indicated phenmedipham might provide a second effective mode of action and mixture partner for common ragweed control with Stinger HL. Field experiments in 2023 and greenhouse experiments in 2023-24 were designed to fill in knowledge gaps.

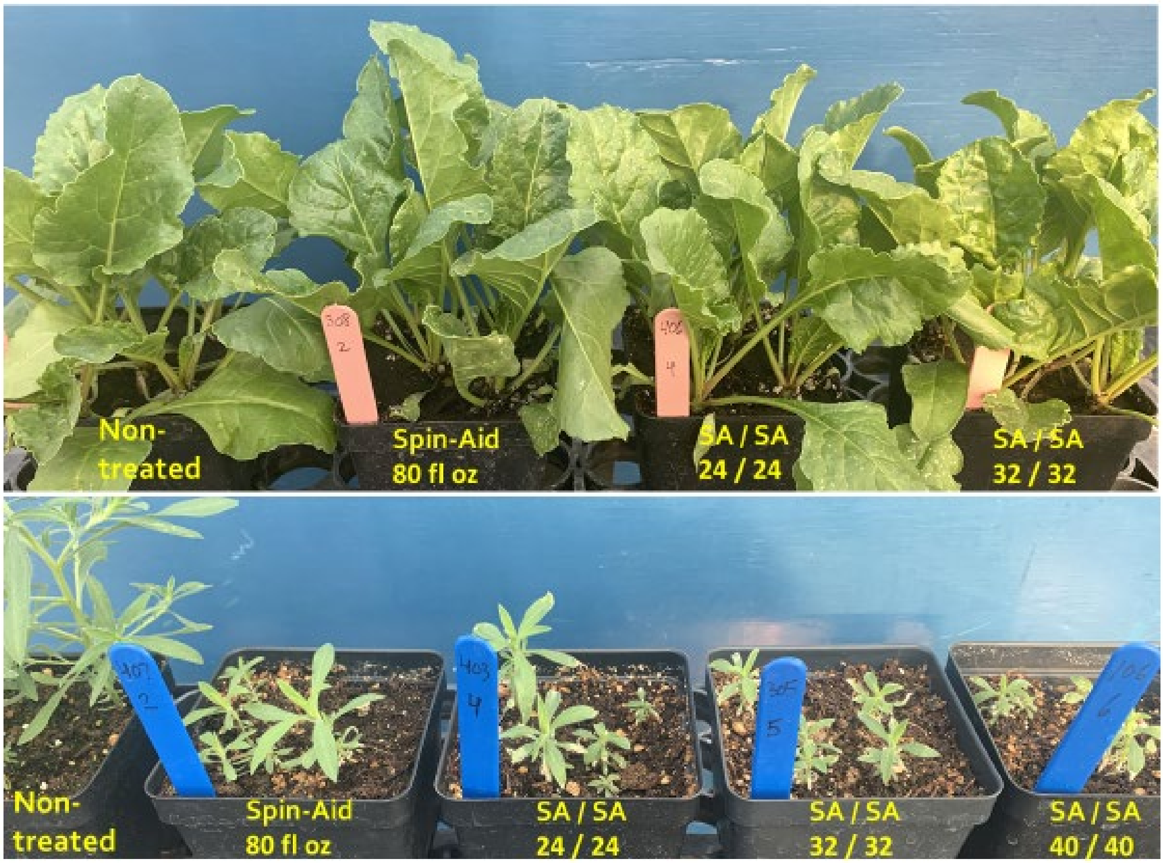

Figure 1. Sugarbeet tolerance or kochia control in response to Spin-Aid singly or repeat Spin-Aid applications after 7 days (sugarbeet) or after 6 days (kochia), greenhouse, 2023.

Objective

Determine selective kochia, common lambsquarters and common ragweed control from Spin-Aid alone, 2- or 3-times Spin-Aid applications, or Spin-Aid following ethofumesate applied PRE. Spin-Aid was applied singly or mixed with ethofumesate and/or Roundup PowerMax3.

Materials and Methods

Tolerance experiments. Sugarbeet tolerance experiments were conducted near Crookston, MN and Hickson, ND in 2023 to evaluate potential variety response from high rates of Spin-Aid. Primary tillage in the fall was followed by secondary tillage using a cultivator with rolling baskets to prepare the seedbed for sugarbeet planting at both locations. Fertilization followed local practices for sugarbeet. Sugarbeet was seeded in 22-inch rows at populations ranging from approximately 63,000 to 65,000 seeds per acre or approximately 4.5- to 4.4-inch spacing, respectively, between seeds. A soil residual herbicide was applied across the experimental area at both locations to control waterhemp. Treatments in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Weeds, insects and diseases were managed throughout the growing season.

Table 1. Sugarbeet hybrid and Spin-Aid rate at the 2- to 4-lf stage.

Factor A Sugarbeet Hybrid[a]	Factor B Spin-Aid rate (pt/A)[b]	Sugarbeet stage (lvs)
CR 137	PowerMax3/PowerMax3	2-4 /10 days
CR 793	4.5	2-4
CR 793	9	2-4
CR 130	4.5	2-4
CR 130	9	2-4
CR 137	4.5	2-4
CR 137	9	2-4

[a]Crystal Sugarbeet Seed
[b]Noble Methylated Seed Oil (MSO) at 1 pt/A with Spin-Aid or Prefer 90 NIS and Amsol liquid AMS at 0.25%+2.5% v/v with Spin-Aid or Roundup PowerMax3

Sugarbeet counts (middle 2 rows x 20' plot length) at 2- to 4-lf stage and preharvest and % visible necrosis and growth reduction injury (0 to 100% scale, 0 is no visible necrosis or growth reduction injury compared to a glyphosate control and 100% complete loss of plant / stand compared to the glyphosate control) were collected 7 days after 2-lf stage application and 3, 7, and 14 days after 2- to 4-lf stage application. Root yield, % sucrose, % purity, and recoverable sucrose were calculated after harvest.

<u>Efficacy experiments.</u> Weed control experiments were conducted near Manvel, ND and Beltrami, MN in 2023 to evaluate kochia, common ragweed, and common lambsquarters control in sugarbeet. Treatments are in Table 2. Experiments evaluated sugarbeet tolerance and efficacy from Spin-Aid plus ethofumesate either singly or two-times applications. Experiments near Manvel were prepared for planting and planted by our grower cooperator. The experimental area near Beltrami, MN was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at approximately 64,000 seeds per acre with 4.5 inch spacing between seeds. Dual Magnum at 1 pt/A was applied across the experimental area to control waterhemp. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

Sugarbeet growth reduction injury and kochia, common ragweed, and common lambsquaters control was evaluated approximately 7 and 14 days after treatment (DAT) with a 0 to 100% scale (0% denoting no sugarbeet injury or kochia, common ragweed, and common lambsquarters control and 100% denoting complete loss of sugarbeet stature/stand or kochia, common ragweed and lambsquaters control). All evaluations were a visible estimate of injury or control in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Table 1. Spin-Aid rate and weed species stage at application, 2023.

Herbicide treatment[a]	Rate (fl oz/A)	Weed species stage (inch)
Spin-Aid + etho[b]	16 + 4	<2
Spin-Aid + etho	24 + 4	<2
Spin-Aid + etho	32 + 4	<2
Spin-Aid + etho	48 + 5	<2
Spin-Aid + etho	72 + 8	<2
Spin-Aid + etho	96 + 11	<2
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	<2 + 7 days
Etho / Spin-Aid + etho	6 / 48 + 5	PRE/ 2
Etho / Spin-Aid + etho	6 / 96 + 11	PRE / 2

[a]Spin-Aid plus Noble methylated seed oil (MSO) at 1.25% v/v.
[b]Etho=ethofumesate.

Results and Discussion

Tolerance experiments. Betanal was used at rates up to 96 fl oz/A for kochia control in the 1970s. Extension Sugarbeet Agronomists observed varietal response from Betanal and suggested an experiment with hybrids representing germplasm diversity (personal communication with Drs. Dexter and Cattanach). Historical research with phenmedipham observed increased growth reduction amongst different sugarbeet varieties. Spin-Aid at 4.5 pt/A (72 fl oz) or 9.0 pt/A (144 fl oz/A) injured sugarbeet (Table 2). However, injury was not dependent on sugarbeet hybrid. Likewise, Spin-Aid rate did not influence yield components measured across diverse sugarbeet hybrids.

Table 2. Sugarbeet growth reduction and yield components in response to Spin-Aid and sugarbeet genetics, across two locations, 2023.

Factor A Sugarbeet Hybrid[a]	Factor B Spin-Aid rate[b]	Sugarbeet Growth Reduction 10 DAAA[c]	Sugarbeet Growth Reduction 39 DAAA	Root Yield	Sucrose	Recoverable Sucrose
	-pt/A-	----------%----------		--TPA--	--%--	--lb/A--
CR 137	glyphosate	3	3	40.4	18.1	13,376
CR 137	4.5	31	7	37.2	17.8	12,208
CR 137	9	42	10	38.6	18.1	12,780
CR 793	4.5	28	11	38.7	17.7	12,838
CR 793	9	42	13	38.2	17.9	12,424
CR 130	4.5	24	5	40.0	18.1	13,337
CR 130	9	38	8	40.4	18.2	13,591
P-Value (0.05)		**0.0941**	**0.3462**	**0.1498**	**0.7457**	**0.1771**

[a]Crystal Sugarbeet Seed

[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.

[c]DAAA= Days after application A.

Efficacy experiments. Sugarbeet injury ranged from 1% to 57%, 10 days after application C (DAAC) following Spin-Aid plus ethofumesate application at the 2-lf stage (Table 3). Sugarbeet injury was necrosis injury, sugarbeet stature reduction, and thinning of sugarbeet stand, especially at Spin-Aid rates in excess of 48 fl oz/A. Based on experience, sugarbeet injury greater than 35% likely will affect yield components. Two-times Spin-Aid and ethofumesate application at 24, 32, and 48 fl oz/A with ethofumesate at 4 fl oz/A did not or tended to not increase sugarbeet injury as compared with Spin-Aid and ethofumesate singly. Likewise, Spin-Aid following ethofumesate PRE did not cause additional sugarbeet injury, 10 DAAC.

Common lambsquarters control ranged from 42% to 95% and 25% to 96%, 10 and 20 DAAC, respectively (Table 3). Common lambsquarters control increased as Spin-Aid rate increased; however, common lambsquarters control was best when Spin-Aid was applied in repeat applications. Split Spin-Aid applications were the same Spin-Aid rate; however, were applied at the 2-lf sugarbeet stage plus 5-days in these experiments. We learned in the greenhouse that sugarbeet safety improves when Spin-Aid rate increases as sugarbeet stage increases (data not presented). The safe rate for cotyledon, 2-lf, and 4-lf sugarbeet is 16, 24, and 32 fl oz/A, respectively.

Table 3. Sugarbeet growth reduction and common lambsquarters control, 2023[a].

Herbicide treatment[b]	Rate	Sugarbeet Growth Reduction	Common Lambsquarters Control 10 DAAC[c]	Common Lambsquarters Control 20 DAAC
	--fl oz/A--	--------%	--------	--------
Spin-Aid + etho	16 + 4	1 a	42 de	33 c
Spin-Aid + etho	24 + 4	5 ab	38 e	25 c
Spin-Aid + etho	32 + 4	23 bcd	60 cd	58 b
Spin-Aid + etho	48 + 5	22 bcd	69 bc	60 b
Spin-Aid + etho	72 + 8	57 f	89 ab	88 a
Spin-Aid + etho	96 + 11	55 f	94 a	95 a
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	33 cde	88 ab	93 a
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	30 cde	85 ab	84 a
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	40 def	95 a	96 a
Etho / Spin-Aid + etho	6 / 48 + 5	15 abc	71 bc	60 b
Etho / Spin-Aid + etho	6 / 96 + 11	45 ef	86 ab	81 a
P-Value (0.05)		**0.0005**	**0.0012**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.

Kochia control from Spin-Aid mixed with ethofumesate ranged from 30% to 90%, 10 DAAC (Table 4). Control tended to increase as Spin-Aid and ethofumesate rate increased, especially 20 DAAC. Kochia control was greatest or tended to be greatest from split Spin-Aid applications. We observed the greatest numeric control of kochia with ethofumesate PRE followed by a single Spin-Aid at 96 fl oz/A application (Table 4).

Table 4. Kochia and common ragweed control, 2023[a].

Herbicide treatment[b]	Rate	Kochia Control 10 DAAC[c]	Kochia Control 20 DAAC	Common Ragweed Control 10 DAAC	Common Ragweed Control 20 DAAC
	--fl oz/A--	--------	--------%	--------	--------
Spin-Aid + etho	16 + 4	40 cde	30 c	8 c	5 e
Spin-Aid + etho	24 + 4	30 e	15 c	18 c	0 e
Spin-Aid + etho	32 + 4	33 de	68 a	18 c	5 e
Spin-Aid + etho	48 + 5	71 abcd	63 ab	15 c	28 d
Spin-Aid + etho	72 + 8	73 abc	72 a	43 b	40 cd
Spin-Aid + etho	96 + 11	65 abcd	70 a	60 ab	58 abc
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	74 abc	83 a	58 ab	50 bc
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	80 ab	75 a	70 a	65 ab
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	90 a	78 a	68 a	74 a
Etho / Spin-Aid + etho	6 / 48 + 5	58 bcde	33 bc	.[d]	.
Etho / Spin-Aid + etho	6 / 96 + 11	88 a	80 a	.	.
P-Value (0.05)		**0.0027**	**0.0008**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.
[d]Data missing. This experiment was implemented later in the season, so we were unable to evaluate ethofumesate PRE.

The 1980 Sugarbeet Production Guide lists Betanal as providing fair to good control on common ragweed. Control was improved when ethofumesate was mixed with Betanal. We observed similar common ragweed control in the field; common ragweed control ranging from 0% to 74%, 20 DAAC. Common ragweed control increased as Spin-Aid rate increased, similar to common lambsquarters and kochia control. We observed greatest common ragweed control from split Spin-Aid applications, especially Spin-Aid at 32 to 48 fl oz/A plus ethofumesate.

Greenhouse research with Spin-Aid continues and has focused on one-, two-, or three-times Spin-Aid + ethofumesate applications for kochia control, starting on 5-lf kochia, less than 1-inch in diameter (we call it dime size) and cotyledon to 2-lf sugarbeet. It will be paramount that our producers target small kochia. Spin-Aid translocates acropetally from the targeted leaves to leaf margins but movement is greater in common lambsquarters and wild mustard than kochia or common ragweed (Hendrick et al. 1974). Conditions at application affect Spin-Aid selective control; activity is less during cool temperatures and low light conditions as compared with warm temperature and direct sunlight conditions (Abbaspoor and Streibig 2007). Risk of injury is increased by temperatures over 80 F and sudden changes from a cool, cloudy environment to a hot, sunny environment (Betamix Best Management Practices (BMPs)). Applications in late afternoon/early evening, when temperatures are decreasing improves sugarbeet safety (Betamix BMPs).

Further investigation suggests Spin-Aid applied three times may improve kochia control as compared with Spin-Aid applied 2-times (Figure 2). In the greenhouse, Spin-Aid at 16 fl oz/A plus ethofumesate at 4 fl oz/A on cotelydon sugarbeet followed by Spin-Aid at 24 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application A (DAAA) followed by Spin-Aid at 32 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application B (DAAB) provided 80% kochia control. Control was greater when Spin-Aid was applied at 32 or 40 fl oz/A the second or third application, respectively. Our greenhouse experiments were conducted with Spin-Aid and ethofumesate plus an MSO adjuvant. We recommend Roundup PowerMax3 integrated into the treatment the first (application A) and third (application C) applications to increase control. Further experiments will explore Spin-Aid mixed with Stinger HL for common ragweed control.

Figure 2. Selective control from Spin-Aid + ethofumesate in a 3-spray program, greenhouse, 2024.

Conclusion
Target kochia less than 1-inch tall kochia (dime size). Align Spin-Aid rate to sugarbeet growth stage, especially if kochia has emerged. Plan for repeat Spin-aid applications on 5-day intervals for GR kochia control. Account for ethofumesate applied PRE in POST program (Table 5).

Table 5. Kochia control in sugarbeet.

Sugarbeet Stage (leaf stage)	Alone Spin-Aid + ethofumesate (fl oz/A)	Following soil residual herbicide Spin-Aid + ethofumesate (fl oz/A)
Cotyledon	16 + 4	12 + 4
2 lf	24 + 4	16 + 4
4-lf	32 + 4	24 + 4
6-lf	40 + 4	32 + 4

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