Gold Section: Sugarbeet Weed Control **Page**

TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2021

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The sixth annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2022 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2021 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND, and Willmar, MN, Grower Seminars. Respondents from seminars in North Dakota indicated the county in which the majority of their sugarbeet were produced (Tables 1, 2, 3, 4). Survey results represent approximately 162,042 acres reported by 168 respondents (Table 5) compared with 193,050 acres represented in 2019. The average sugarbeet acreage per respondent grown in 2021 was calculated from Table 5 at 965 acres compared with 697 acres in 2019.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2021. Sixty percent of respondents indicated wheat was the crop preceding sugarbeet (Table 6), 26% indicated corn, and 10% indicated soybean. Preceding crop varied by location with 94% of Grand Forks growers indicating wheat preceded sugarbeet and 70% of Willmar growers indicated corn as their preceding crop. Eighty-two percent of growers who participated in the winter meetings used a nurse or cover crop in 2021 (Table 7) which increased from 77% in 2019. Cover crop species also varied widely by location with wheat being used by 40% of growers at the Grafton meeting and barley being used by 57% of growers at the Wahpeton meeting.

Growers indicated weeds were their most serious production problem in sugarbeet in 2021 (Table 8) with 32% of all respondents naming weeds compared with CLS (Cercospora Leaf Spot) being named most serious problem by 42% of participants in 2019. In 2021, CLS was the most serious problem for 29% of respondents and emergence or stand was named as most serious by 23% of respondents.

Waterhemp was named as the most serious weed problem in sugarbeet in 2021 by 73% of respondents (Table 9) compared with 54% in 2019. Thirteen percent of respondents indicated kochia, 7% said common ragweed, and 3% of respondents indicated common lambsquarters were their most serious weed problem in 2021. The increased presence of glyphosate-resistant waterhemp and kochia are likely the reason for these weeds being named as the worst weeds. Troublesome weeds varied by location with greater than 93%, 89%, and 93% of Willmar, Wahpeton, and Fargo respondents, respectively, indicating waterhemp was most problematic weed. Kochia was the worst weed for respondents of the Grafton meeting with 57% of responses.

Respondents to the survey indicated making 0 to 5 glyphosate applications in their 2021 sugarbeet crop (Table 10) with a calculated average of 1.99 applications per acre. The calculated average in 2019 was 2.16 applications per acre.

Glyphosate was most commonly applied with a chloroacetamide herbicide postemergence (lay-by) in 2021 with 49% of responses indicating this herbicide combination was used (Table 11). Glyphosate applied with a broadleaf herbicide postemergence was the second most common herbicide used in sugarbeet in 2021 with 31% of responses. Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 10% and 7% of the responses, respectively.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 75% of survey respondents in 2021 (Table 12). Thirty-one percent of Grafton survey participants applied a PPI or PRE herbicide compared with 13% in 2019. Conversely, 90% of Wahpeton survey participants applied a PPI or PRE herbicide in sugarbeet in 2021 compared with 89% in 2019. Once again, a likely reason for this variation is the more common presence of glyphosate-resistant waterhemp in the southern sugarbeet growing areas of the Red River Valley compared with the north end of the Valley. The most commonly used soil herbicide was *S*-metolachlor with 32% of all responses followed by a combination of *S*-metolachlor plus ethofumesate with 25% of responses. Of the growers who indicated using a soil-applied herbicide, 51% indicated excellent to good weed control from that herbicide (calculated from Table 13).

The application of soil-residual herbicides applied 'lay-by' to the 2021 sugarbeet crop was indicated by 86% of respondents (Table 14). *S*-metolachlor was the most commonly applied lay-by herbicide with 45% of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (83% of responses), while S-metolachlor was more commonly applied by growers of the Fargo (93% of responses) and Wahpeton (62% of responses) meetings.

Satisfaction of weed control from lay-by applications ranged from excellent to unsure (Table 15). Of respondents indicating they applied a lay-by herbicide, 78% indicated good or fair weed control (calculated from Table 15). Less than normal rainfall in April and May reduced the efficacy of PRE, early postemergence (EPOST), and postemergence (POST) applied soil-residual herbicides.

The Environmental Protection Agency (EPA) approved a 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 waterhemp in sugarbeet in 2021. 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. Thirty-seven percent of respondents applied Ultra Blazer in 2021 (Table 16). Of the growers who used Ultra Blazer, 14% applied Ultra Blazer alone, 12% applied Ultra Blazer with NIS and 8% tank mixed Ultra Blazer with glyphosate, NIS, and AMS.

Satisfaction of weed control from Ultra Blazer ranged from excellent to poor (Table 17). Of respondents indicating they applied Ultra Blazer, 27% indicated excellent to good weed control (calculated from Table 17).

Row-crop cultivation of the 2021 sugarbeet crop was reported by 32% of respondents (calculated from Table 18). Twelve percent reported row-crop cultivation on less than ten percent of their acres (Table 18). Conversely, 8% reported row-crop cultivation on 100% of their acres.

Hand-weeding the 2021 sugarbeet crop was reported by 75% of respondents (Table 19). Most respondents who hand-weeded indicated 10-50% of their acres were hand-weeded. Fewer than half of the respondents indicated hand-weeding at the Fargo meeting, while greater than half the participants at the Grafton, Grand Forks, and Willmar meetings reported some hand weeding.

Table 1. 2022 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Cass	2	29
Clay	1	14
Norman[1]	2	29
Richland	1	14
Traill	1	14
Total	7	100

[1]Includes Mahnomen County

Table 2. 2022 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Grand Forks	1	6
Kittson	1	6
Marshall	2	13
Pembina	4	25
Walsh	6	37
Other	2	13
Total	16	100

Table 3. 2022 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Grand Forks	7	18
Mahnomen	1	3
Marshall	2	5
Polk	17	43
Traill	1	3
Walsh	2	5
Other	9	23
Total	39	100

Table 4. 2022 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Clay	7	10
Grant	6	9
Richland	16	25
Traverse	3	5
Wilkin	33	51
Total	65	100

Table 5. Total sugarbeet acreage operated by respondents in 2021.

		Acres of sugarbeet									
Location	Responses	<99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		% of responses									
Fargo	12	17	0	0	17	17	8	0	17	17	8
Grafton	16	13	6	0	13	19	6	19	13	6	6
Grand Forks	38	13	8	2	11	16	11	11	8	2	18
Wahpeton[1]	65	0	11	0	34	0	17	38	0	0	0
Willmar	37	24	5	11	3	16	14	3	16	5	3
Total	168	11	8	3	5	23	7	11	8	18	6

[1]Acreage categories were <250, 250-500, 500-750, or >750.

Table 6. Crop grown in 2020 that preceded sugarbeet in 2021.

		Previous Crop								
Location	Responses	Barley	Canola	Sweet Corn	Field Corn	Dry Bean	Potato	Soybean	Wheat	Other
		% of responses								
Fargo	14	0	0	0	0	0	0	7	86	7
Grafton	15	0	0	0	0	20	7	7	66	0
Grand Forks	39	0	0	0	3	0	0	0	94	3
Wahpeton	65	0	0	0	14	0	0	20	66	0
Willmar	40	0	0	20	70	0	0	8	3	0
Total	173	0	0	5	21	2	1	10	60	1

Table 7. Nurse or cover crop used in sugarbeet in 2021.

Location	Responses	Barley	Oat	Rye	Wheat	Other[1]	None
		% of responses					
Fargo	10	30	0	0	30	0	40
Grafton	15	40	7	0	40	0	13
Grand Forks	38	55	0	3	18	0	24
Wahpeton	62	57	3	8	19	2	11
Willmar[2]	-	-	-	-	-	-	-
Total	125	52	2	5	22	1	18

[1]Includes Mustard and 'Other'
[2]Information not collected during Wilmar Grower Seminar.

Table 8. Most serious production problem in sugarbeet in 2021.

Location	Responses	CLS[1]	Rhizo-mania	Aph[2]	Rhizoc-tonia	Fusarium	Herbicide Injury	Root Maggot	Weeds	Stand[3]
		% of responses								
Fargo	14	58	0	0	14	7	0	0	7	14
Grafton	17	59	0	6	0	0	0	12	6	17
Grand Forks	39	36	0	0	8	0	0	2	26	28
Wahpeton	63	21	0	0	13	0	2	0	41	23
Willmar	40	15	0	0	13	0	5	0	43	24
Total	173	29	0	1	10	1	2	2	32	23

[1]Cercospora Leaf Spot
[2]Aphanomyces
[3]Emergence/Stand

Table 9. Most serious weed problem in sugarbeet in 2021.

Location	Responses	palmer[1]	colq	cora	kochia	gira	rrpw	RR Canola	wahe
		-----------------------------------% of responses--------------------------							
Fargo	14	0	0	7	0	0	0	0	93
Grafton	14	0	7	0	57	0	7	7	22
Grand Forks	39	0	8	26	23	5	3	3	32
Wahpeton	65	0	2	2	5	0	2	0	89
Willmar	43	0	2	0	5	0	0	0	93
Total	175	0	3	7	13	1	2	1	73

[1]palmer=palmer amaranth, colq=common lambsquarters, cora=common ragweed, gira=giant ragweed, rrpw=redroot pigweed, wahe=waterhemp

Table 10. Average number of glyphosate applications per acre in sugarbeet during 2021 season.

Location	Responses	0	1	2	3	4	5
		-------------------------% of responses----------------------------					
Fargo	11	0	27	73	0	0	0
Grafton	11	0	27	55	18	0	0
Grand Forks	39	3	5	82	10	0	0
Wahpeton	64	0	16	64	20	0	0
Willmar[1]	-	-	-	-	-	-	-
Total	125	1	14	70	15	0	0

[1]Information not collected during Wilmar Grower Seminar.

Table 11. Herbicides used in a weed control systems approach in sugarbeet in 2021.

		Glyphosate Application Tank-Mixes					
Location	Responses	Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		-------------------------------------% of responses----------------------------------					
Fargo	17	6	59	35	0	0	0
Grafton[1]	-	-	-	-	-	-	-
Grand Forks	30	18	43	37	0	0	2
Wahpeton[1]	-	-	-	-	-	-	-
Willmar	40	5	78	35	25	5	0
Total	87	10	49	31	7	2	1

[1]Information not collected during Grafton or Wahpeton Grower Seminar.

Table 12. Preplant incorporated or preemergence herbicides used in sugarbeet in 2021.

		PPI or PRE Herbicides Applied					
Location	Responses	S-metolachlor	ethofumesate	Ro-Neet SB	S-metolachor +ethofumesate	Other	None
		-------------------------------------% of responses----------------------------------					
Fargo	17	53	23	0	12	0	12
Grafton	13	15	8	0	8	0	69
Grand Forks	43	22	12	0	12	5	49
Wahpeton	67	42	12	0	33	3	10
Willmar	41	22	27	0	37	0	15
Total	181	32	16	0	25	2	25

Table 13. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2021.

		PPI or PRE Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		------------------------------% of responses--------------------------					
Fargo	14	21	50	21	0	0	7
Grafton	10	0	20	10	10	0	60
Grand Forks	38	0	40	13	0	0	47
Wahpeton	65	3	62	25	6	0	4
Willmar	42	2	36	40	7	5	10
Total	169	4	47	25	5	1	18

Table 14. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2021.

		Lay-by Herbicides Applied				
Location	Responses	S-metolachlor	Outlook	Warrant	Other	None
		--% of responses--------------------------------------				
Fargo	14	93	7	0	0	0
Grafton	11	18	9	0	0	73
Grand Forks	41	49	10	2	2	37
Wahpeton	64	62	34	2	0	2
Willmar	41	10	83	15	2	2
Total	171	45	35	5	1	14

Table 15. Satisfaction of weed control from soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2021.

		Lay-by Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		-------------------------------% of responses--------------------------					
Fargo	12	34	50	8	8	0	0
Grafton	12	0	8	17	17	0	58
Grand Forks	46	9	48	9	4	4	26
Wahpeton	61	2	57	36	3	0	2
Willmar	43	5	37	51	5	0	2
Total	174	7	46	29	5	1	12

Table 16. Herbicides applied with Ultra Blazer in sugarbeet in 2021.

		Ultra Blazer Application Tank-Mixes					
Location	Responses	UB Alone	UB+NIS	UB+Gly	UB+Gly+NIS+AMS	Unsure	None Used
		------------------------------------% of responses----------------------------------					
Fargo	11	0	27	0	9	0	64
Grafton	12	0	0	0	0	0	100
Grand Forks	46	4	10	4	4	0	78
Wahpeton	62	32	13	2	8	0	45
Willmar	37	3	14	5	16	0	62
Total	168	14	12	3	8	0	63

Table 17. Satisfaction in weed control from Growers' reporting Ultra Blazer applied in sugarbeet in 2021.

		Satisfaction of Weed Control from Ultra Blazer			
Location	Responses	Excellent	Good	Fair	Poor
		--------% of responses--------			
Fargo	3	0	33	67	0
Grafton	1	0	0	100	0
Grand Forks	11	0	45	55	0
Wahpeton	33	4	18	42	36
Wilmar	13	0	23	46	31
Total	61	2	25	47	26

Table 18. Percent of sugarbeet acres row-crop cultivated in 2021.

		% Acres Row-Cultivated				
Location	Responses	0	< 10	10-50	51-100	>100
		--------% of responses--------				
Fargo	9	67	22	11	0	0
Grafton	13	62	23	15	0	0
Grand Forks	45	84	13	3	0	2
Wahpeton[1]	-	-	-	-	-	-
Willmar	36	53	6	14	6	22
Total	103	68	12	10	2	8

[1]Information not collected during Wahpeton Grower Seminar.

Table 19. Percent of sugarbeet acres hand-weeded in 2021.

		% Acres Hand-Weeded				
Location	Responses	0	< 10	10-50	51-100	>100
		--------% of responses--------				
Fargo	11	55	36	0	0	9
Grafton	11	46	36	18	0	0
Grand Forks	45	31	53	16	0	0
Wahpeton[1]	-	-	-	-	-	-
Willmar	34	35	29	15	12	9
Total	101	25	29	40	3	3

[1]Information not collected during Wahpeton Grower Seminar.

CONTROLLING WATERHEMP ESCAPES IN SUGARBEET

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Summary

1. Ultra Blazer broadcast applied, Liberty or Gramoxone applied with the hooded sprayer, or inter-row cultivation at the 10- to 12-lf sugarbeet stage all improved escaped waterhemp control compared with ethofumesate preemergence (PRE) banded followed by repeat (3x) glyphosate plus ethofumesate applications at Blomkest and Moorhead in 2020 and 2021.
2. Treatment at the 10- to 12-lf sugarbeet stage complemented herbicide applications applied at the PRE, 2- to 4-lf, and 6- to 8-lf sugarbeet stage.
3. Apply chloroacetamide herbicide mixtures with glyphosate and ethofumesate at the 2- to 4-lf sugarbeet stage, even when following ethofumesate PRE.

Introduction

Sugarbeet growers use layered application of soil residual herbicides applied preemergence (PRE), early postemergence (EPOST), and postemergence (POST) to manage waterhemp in sugarbeet. These herbicides control waterhemp only after they are incorporated into the soil by rainfall. Soil residual herbicides do not control emerged weeds or weed escapes and must be addressed with the POST portion of a weed management program. Escaped waterhemp control is challenging since we currently do not have a POST herbicide effective for control of glyphosate-resistant waterhemp in sugarbeet.

We evaluated a series of 'ideas' to control waterhemp escapes in sugarbeet including inter-row applications of Liberty with the Redball™ 915 hooded sprayer (24c) and inter-row cultivation in 2020 as well as inter-row applications of Liberty or Gramoxone (not approved in sugarbeet) with the Redball™ 915 hooded sprayer, inter-row cultivation, and Ultra Blazer (Section 18) in 2021. The objective of these experiments was to evaluate sugarbeet tolerance and control of escaped glyphosate-resistant waterhemp using these alternative weed control methods.

Materials and Methods

Experiments were conducted on natural populations of waterhemp in a sugarbeet grower's field near Blomkest, MN in 2020 and 2021 and on our research farm near Moorhead, MN in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and conducting tillage across the experimental area at each location. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds.

Herbicide treatments were designed to create waterhemp escapes in plots that would then be treated at the 10- to 12-leaf sugarbeet stage. Herbicide treatments were ethofumesate PRE broadcast or PRE band-applied followed by Dual Magnum mixtures with Roundup PowerMax plus ethofumesate POST applied at the 2-4 and 6-8 sugarbeet leaf stage. Preemergence broadcast and POST treatments were applied with a bicycle sprayer in 17 gpa spray solution through TeeJet 8002 XR-flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length. Preemergence band treatments were applied in 11-inch strips over the center four rows of six row plots with a bicycle sprayer in 17 gpa spray solution through TeeJet 4002E nozzles pressurized with CO_2 at 40 psi.

Treatment for control of waterhemp escapes were applied at the 10- to 12-leaf sugarbeet stage and included: a) inter-row cultivation performed using a modified Alloway 3130 cultivator (Alloway Standard Industries, Fargo, ND) with 15-inch sweep shovels with a ground depth of 1.5- to 2-inch at 4 mph; b) inter-row application of Liberty or Gramoxone through TeeJet 8002 EVS nozzles pressurized with CO_2 at 40 psi with the Redball™ 915 hooded sprayer (Willmar Fabrication, LLC, Benson, MN) and c) broadcast application of Ultra Blazer applied with a bicycle sprayer in 17 gpa spray solution through TeeJet 8002 XR-flat fan nozzles pressurized with CO_2 at 40 psi. Herbicide treatments for 2020 experiment at Blomkest and Moorhead are found in Table 1 and herbicide treatments for the 2021 experiment at Blomkest are found in Table 2.

The Moorhead location was harvested in 2020. Sugarbeet were defoliated and the center two or three rows of each plot was harvested mechanically and weighed. Experimental design was randomized complete block with four replications. About a 20 lb. root sample was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Data from all experiments were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Herbicide treatment, herbicide rate, application method and application timing in 2020, Blomkest and Moorhead, MN.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax[1] + ethofumesate / Roundup PowerMax + ethofumesate	96 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty[3] Hooded sprayer	48 / 16 + 32 + 12 / 32	PRE / 4 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty Hooded sprayer	48 / 16 + 32 + 12 / 32	PRE / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 32 + 12 / mechanical	PRE / 4 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 32 + 12 / mechanical	PRE / 8 lf / 10-12 lf

[1]Roundup PowerMax + ethofumesate was applied with Destiny HC @ 1.5 pt/A + Amsol Liquid AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Liberty applied with Dry AMS at 3 lb/A.

Table 2. Herbicide treatment, herbicide rate, application method and application timing in 2021, Blomkest, MN.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax[1] + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty[3] Hooded sprayer	48 / 16 + 28 + 6 / 16 + 28 + 6 / 38	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Gramoxone 3.0 SL Hooded sprayer	48 / 16 + 28 + 6 / 16 + 28 + 6 / 24	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 28 + 6 / 16 + 28 + 6 / mechanical	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax[4]	48 / 16 + 28 + 6 / 16 + 28 + 6 / 16 + 22	PRE / 4 lf / 8 lf / 10-12 lf

[1]Roundup PowerMax + ethofumesate was applied with Destiny HC @ 1.5 pt/A + Amsol Liquid AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Liberty applied with Dry AMS at 3 lb/A.
[4]Ultra Blazer + Roundup PowerMax applied with Prefer 90 NIS @ 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Results

Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 2- to 4-lf stage provided waterhemp control greater than Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 6- to 8-lf stage at Blomkest and Moorhead in 2020 (data not presented). Both treatments followed ethofumesate PRE in an 11-inch band at 6 pt/A in the treated area.

Results will focus on control of escaped waterhemp with inter-row cultivation, Roundup PowerMax mixed with ethofumesate, and inter-row application of Liberty with the hooded sprayer at the 10- to 12-lf stage. These POST treatments followed either ethofumesate PRE (broadcast or in a band application) and repeat applications of Roundup PowerMax plus ethofumesate, or ethofumesate PRE in a band followed by Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 2- to 4-lf stage.

We observed sugarbeet injury ranging from 5% to 18%, 39 days after planting (DAP) at Blomkest in 2020 (Table 3). Injury was random within plots and seemed to be related to field variation caused by dry soil conditions; not herbicide treatment. Waterhemp control was greater than 85% across treatments at 47 DAP. Ethofumesate PRE in a band application tended to provide less control than ethofumesate PRE as a broadcast application when followed by Roundup PowerMax plus ethofumesate as well as ethofumesate PRE in a band application when followed by Dual Magnum plus Roundup PowerMax and ethofumesate. However, early season control was generally good across all treatments.

Table 3. Sugarbeet injury and waterhemp control in response to PRE and EPOST herbicides, and POST treatment control of escaped waterhemp 8 and 17 DAT, Blomkest, MN, 2020.[a]

PRE / EPOST Herbicide Treatment[b]	Sgbt inj[b] 39 DAP[c]	Wahe[b] Control 47 DAP	POST Treatment[b]	Wahe Control 8 DAT[c]	Wahe Control 17 DAT
	----------%----------			----------%---------	
Etho (broadcast) / PM + etho / PM + etho	18	100 a	Roundup PowerMax + etho	99 a	99 a
Etho (band) / PM + etho / PM + etho/	11	89 b	Roundup PowerMax + etho	69 b	79 b
Etho (band) / Dual + PM + etho / Dual + PM + etho	5	96 ab	Liberty with Redball™ 915 hooded sprayer	93 a	91 a
Etho (band) / Dual + PM + etho / Dual + PM + etho	18	100 a	Inter-row cultivation	100 a	99 a
LSD (0.10)	**NS**	**8**		**10**	**11**

[a]Means within a column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; sgbt inj=sugarbeet injury; wahe = waterhemp.
[c]DAP = days after plant; DAT = days after treatment.

Greater than 90% control of up to 6-inch escaped waterhemp was observed from the POST application of Roundup PowerMax plus ethofumesate, Liberty with the hooded sprayer, or with inter-row cultivation when following ethofumesate applied PRE broadcast. Control from these POST treatments was significantly greater than Roundup PowerMax plus ethofumesate when following ethofumesate PRE applied in the band. These results support the idea of controlling escaped waterhemp using either the hooded sprayer or inter-row cultivation.

Sugarbeet injury was negligible in the Moorhead experiment in 2020 (data not presented). Waterhemp control at 28 DAP was greater than 80% (Table 4). Control of escaped waterhemp was greatest with inter-row cultivation. Waterhemp control was least with inter-row application of Liberty with the hooded sprayer or from ethofumesate PRE band-applied followed by three Roundup PowerMax plus ethofumesate applications. No differences were observed in sugarbeet root yield (data not presented), % sucrose, or recoverable sucrose per acre. However, recoverable sucrose per acre following waterhemp control with cultivation tended to be greater than recoverable sucrose from other treatments.

Table 4. Waterhemp control 28 DAP in response to PRE and EPOST treatments, and POST treatment control of escaped waterhemp 16 DAT and yield parameters in response to POST treatment, Moorhead, MN, 2020[a].

PRE / EPOST Herbicide Treatment[b]	Wahe[b] Control 28 DAP[c]	POST Treatment[b]	Wahe Control 16 DAT[c]	Sugarbeet Yield Sucrose	Sugarbeet Yield Rec. Suc.[b]
	---%---		-----------%-----------		---lb/A---
Etho (broadcast) / PM + etho / PM + etho	89 ab	Roundup PowerMax + etho	84 b	13.6	6,555
Etho (band) / PM + etho / PM + etho/	81 b	Roundup PowerMax + etho	76 bc	13.3	6,796
Etho (band) / Dual + PM + etho / Dual + PM + etho	91 a	Liberty with Redball™ 915 hooded sprayer	68 c	13.5	6,425
Etho (band) / Dual + PM + etho / Dual + PM + etho	95 a	Inter-row cultivation	99 a	13.7	6,952
LSD (0.10)	**8**		**13**	**NS**	**NS**

[a]Means within column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; wahe = waterhemp, Rec. Suc. = recoverable sucrose.
[c]DAP = days after plant; DAT = days after treatment.

Inter-row cultivation controlled 2- to 4-inch escaped waterhemp at Blomkest (Table 3) and Moorhead (Table 4) in 2020. Inter-row application of Liberty with the hooded sprayer controlled escaped waterhemp at Blomkest but not at

Moorhead. Inconsistent results with the hooded sprayer may have been related to an equipment malfunction at Moorhead rather than the herbicide treatment.

Planned program treatments applied PRE, EPOST, and POST caused negligible sugarbeet injury and provided similar waterhemp control 40 DAP at Blomkest in 2021 (Table 5). Waterhemp control ranged from 75% to 94% with ethofumesate PRE broadcast followed by Roundup PowerMax plus ethofumesate applied at the 4- and 8-lf stages giving the greatest waterhemp control.

Table 5. Waterhemp control 40 DAP in response to PRE and EPOST treatments and POST treatments control of escape waterhemp 2 and 24 DAT, Blomkest, MN, 2021.[a]

PRE / EPOST	Sgbt Inj.[b]	Wahe[b] Control	POST	Sgbt Inj.	Wahe Control	
Herbicide Treatment[b]	40 DAP[c]	40 DAP	Treatment[b]	16 DAT[c]	2 DAT	24 DAT
	---------%--------			--------------%-------------		
Etho (broadcast) / PM + etho / PM + etho	0	94	Roundup PowerMax + etho	0 b	79 bc	78 bc
Etho (band) / PM+etho / PM+etho/	0	79	Roundup PowerMax + etho	0 b	73 c	70 c
Etho (band) / Dual+PM+etho / Dual+PM+etho	4	75	Liberty with Redball™ 915 hooded sprayer	3 b	75 c	86 ab
Etho (band) /Dual+PM+etho / Dual+PM+etho	4	79	Gramoxone with Redball™ 915 hooded sprayer	3 b	90 ab	87 ab
Etho (band) / Dual+PM+etho / Dual+PM+etho	4	78	Inter-row cultivation	0 b	96 a	93 a
Etho (band) / Dual+PM+etho / Dual+PM+etho	0	85	Ultra Blazer+PM+ NIS+ AMS	18 a	81 bc	90 ab
LSD (0.10)	**NS**	**NS**		**9**	**14**	**13**

[a]Means within a column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; sgbt Inj. = sugarbeet injury; wahe = waterhemp.
[c]DAP = days after plant; DAT = days after treatment.

Inter-row application of Gramoxone with the Redball 915 hooded sprayer or inter-row cultivation provided immediate control of 90% and 96%, respectively, 3- to 12-inch escaped waterhemp at 2 DAT. Waterhemp control from Gramoxone via the hooded sprayer was similar to Ultra Blazer plus Roundup PowerMax and similar to Roundup PowerMax plus ethofumesate when following ethofumesate broadcast PRE. Escaped waterhemp control from Gramoxone with the hooded sprayer, inter-row cultivation, Ultra Blazer plus Roundup PowerMax, and Liberty with the hooded sprayer was or tended to be greater than waterhemp control from Roundup PowerMax plus ethofumesate at 24 DAT.

Conclusions

Waterhemp control challenges in sugarbeet is forcing agriculturalists to reconsider weed management strategies and evaluate 10- to 12-lf sugarbeet growth stage treatments. Escaped waterhemp did not reduce yield (Moorhead, 2020) but produced seed that developed into a production challenge for crops grown in sequence with sugarbeet. This research found there are multiple useful tools to control escaped waterhemp including inter-row cultivation, the hooded sprayer, and Ultra Blazer.

A secondary outcome of these experiments was applying ethofumesate PRE in an 11-inch band. This application method could be utilized to save money while maintaining waterhemp control, especially if the producer is using layered residuals or herbicides applied at the 2- to 4- and 6- to 8-lf stage in sugarbeet. Also, observations suggest that the first in-season chloroacetamide application should be timed to 2- to 4-lf stage sugarbeet, even if ethofumesate PRE is applied.

WATERHEMP CONTROL FROM SOIL RESIDUAL HERBICIDES IN A DRY SEASON

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Summary

1. Shallow incorporation of ethofumesate reduces degradation losses.
2. Soil residual herbicides control weeds when they are incorporated into the soil solution.
3. Time application of soil residual herbicides to sugarbeet growth stage rather than rainfall events.
4. Preemergence (PRE) application followed by a split layby application of soil residual herbicides is our best waterhemp control strategy.
5. A third postemergence (POST) application of chloroacetamide herbicide tends to improve waterhemp control but causes increased sugarbeet injury.

Introduction

Waterhemp control in sugarbeet is our most important weed management challenge. Waterhemp is both common and troublesome in fields planted to sugarbeet for multiple reasons. First, sugarbeet is botanically related to waterhemp. Sugarbeet is a member of the Betoidae subfamily within Amaranthaceae which includes approximately 2,500 species. Second, waterhemp are small seeded broadleaf weeds, germinating and emerging near the soil surface in response to moisture and light from May through August. Third, waterhemp are prolific seed producers, capable of producing between 50,000 and 250,000 seeds depending on emergence date, plant size, and competition with the surrounding cultivated crop. Fourth, waterhemp has male and female flowers on separate plants (dioecious). That is, male plants produce pollen while female plants make seed. This unique biology creates tremendous genetic diversity in populations and results in plants that are biologically and morphologically unique. Moreover, waterhemp has a remarkable ability to adapt to control tactics and has evolved resistance to herbicides from many different classes. To date, waterhemp has evolved resistance to herbicides from six classes, including Group 5 (e.g., triazines like atrazine), Group 2 (e.g., ALS-inhibiting herbicides like Pursuit), Group 14 (e.g., PPO-inhibiting herbicides like Ultra Blazer and Flexstar), Group 9 (e.g., glyphosate), Group 27 (e.g., HPPD-inhibiting herbicides like Callisto and Laudis), and Group 4 (e.g., 2,4-D). Finally, waterhemp seeds are viable for up to six years in the soil.

The foundation of the waterhemp control program in sugarbeet has been layered use of chloroacetamide (Group 15) herbicides PRE, early postemergence (EPOST), and POST alone or in combination with glyphosate and ethofumesate in sugarbeet (Figure 1). The goal is to have layered residual herbicides in the soil from planting through canopy closure in late June or early July to control waterhemp emergence.

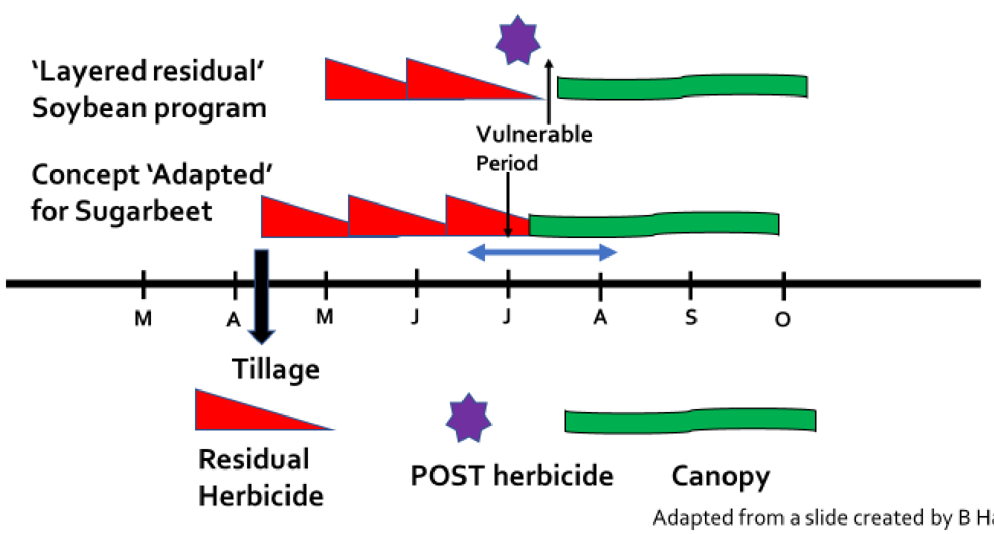

Figure 1. A demonstration of layered soil residual herbicides creating a herbicide barrier in soil from planting through canopy closure.

Our recommendations were developed from experiments conducted in 2014, 2015, and 2016 or seasons when timely rainfall incorporated soil residual herbicide into the soil shortly after application. These trials support a PRE application followed by split lay-by applications (Figure 2). Rainfall has been both localized and sporadic in 2020 and 2021 resulting in early season waterhemp escapes. Further, some producers have questioned if it makes economic sense to apply soil residual herbicides according to sugarbeet growth stage when rain is not in the forecast. Our continued research experiments, specifically 2020 experiments, like producer fields, did not received timely rainfall. The objective of this report is to discuss the performance of herbicides when inadequate activation from rainfall results in the herbicide remaining on the soil surface for days or weeks following application.

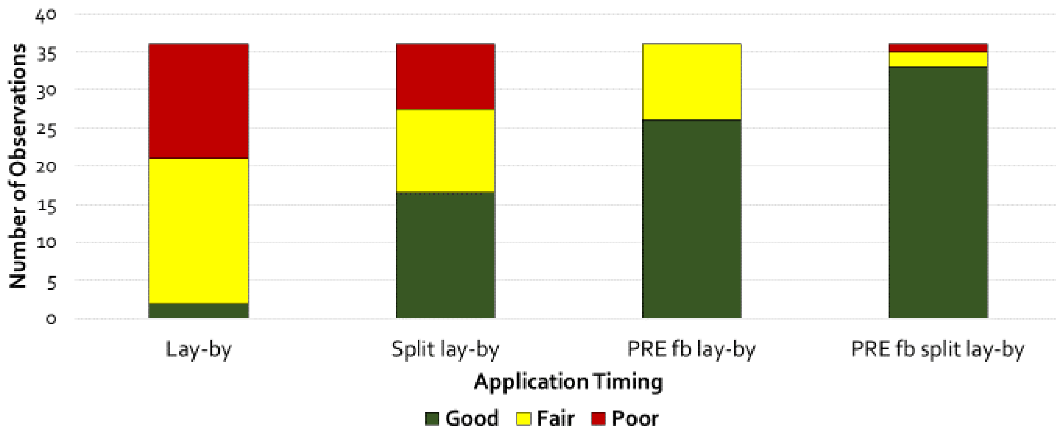

Figure 2. Number of observations with good (greater than 85%), fair (65% to 84%), and poor (less than 64%) waterhemp control in response to herbicide treatment and application timing summed across evaluations and locations, 2014 to 2016.

Materials and Methods

Waterhemp control with ethofumesate

Experiments were conducted near Blomkest and Moorhead, MN in 2020 and near Fargo, ND and Moorhead, MN in 2021. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on April 25 and May 3 at Blomkest and Moorhead, respectively, in 2020 and May 10 and May 12 at Fargo and Moorhead, respectively, in 2021. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds. Herbicide treatments for 2020 experiment at Blomkest and Moorhead are found in Table 1 and herbicide treatments for the 2021 experiment at Fargo and Moorhead are found in Table 2.

Table 1. Herbicide treatments and rate, Blomkest and Moorhead, MN, 2020.

Herbicide Treatment	Application Timing	Rate (pt/A)
Untreated Check		0
Ethofumesate	Preemergence	1.5
Ethofumesate	Preemergence	3
Ethofumesate	Preemergence	4.5
Ethofumesate	Preemergence	6
Ethofumesate	Preemergence	7.5

Table 2. Herbicide treatment, application timing, and rate, Fargo, ND and Moorhead, MN, 2021.

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

Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length in 2020 and 2021. Visible waterhemp control (0 to 100% control, 0% indicating no control, and 100% indicating complete control) was collected approximately 14, 28, 42, 56, and 70 days after treatment (DAT). Experimental design was randomized complete block with four replications in 2020 and randomized complete block design with four replications in a factorial treatment arrangement in 2021, with factors being herbicide treatment and application timing. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Waterhemp control with soil residual herbicides applied PRE and POST

Experiments were conducted near Blomkest and Moorhead, MN in 2021. Treatments are listed in Table 3. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 3 at Blomkest and May 12 at Moorhead in 2021. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length.

Table 3. Herbicide treatment, rate, and application timing, Blomkest and Moorhead, MN, 2021.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (pt/A)	Sugarbeet stage (lvs)
No	Untreated Check		-
No	Warrant	3	2
No	Outlook / Outlook	0.75 / 0.75	2 / 8
No	Warrant / Warrant	3 / 3	2 / 8
No	Outlook / Warrant	0.75 / 3	2 / 8
No	Outlook / Warrant	0.75 / 4	2 / 8
No	Outlook / Warrant / Warrant	0.75 / 3 / 3	2 / 4 / 8
Etho + DM[b]	Untreated Check	2 + 0.5	PRE
Etho + DM	Warrant	2 + 0.5 / 3	PRE / 2
Etho + DM	Outlook / Outlook	2 + 0.5 / 0.75 / 0.75	PRE / 2 / 8
Etho + DM	Warrant / Warrant	2 + 0.5 / 3 / 3	PRE / 2 / 8
Etho + DM	Outlook / Warrant	2 + 0.5 / 0.75 / 3	PRE / 2 / 8
Etho + DM	Outlook / Warrant	2 + 0.5 / 0.75 / 4	PRE / 2 / 8
Etho + DM	Outlook / Warrant / Warrant	2 + 0.5 / 0.75 / 3 / 3	PRE / 2 / 4 / 8
Ethofumesate	Untreated Check	6	PRE
Ethofumesate	Warrant	6 / 3	PRE / 2
Ethofumesate	Outlook / Outlook	6 / 0.75 / 0.75	PRE / 2 / 8
Ethofumesate	Warrant / Warrant	6 / 3 / 3	PRE / 2 / 8
Ethofumesate	Outlook / Warrant	6 / 0.75 / 3	PRE / 2 / 8
Ethofumesate	Outlook / Warrant	6 / 0.75 / 4	PRE / 2 / 8
Ethofumesate	Outlook / Warrant / Warrant	6 / 0.75 / 3 / 3	PRE / 2 / 4 / 8

[a]Roundup PowerMax at 28 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 every POST application, including untreated check.
[b]Etho + DM = ethofumesate + Dual Magnum

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). Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) were collected approximately 14, 28, 42, 56, and 70 DAT. Experimental design was randomized complete block with four replications in a factorial treatment arrangement, factors being PRE and POST herbicide treatments. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Results

Waterhemp control with ethofumesate

Rainfall totals for Blomkest and Moorhead, MN and Fargo, ND from April through August in 2020 and 2021 along with 30-yr averages are presented in Table 4. The number of days between ethofumesate application and the first significant rainfall for incorporating ethofumesate into soil were 1-day at Moorhead in 2020, 21 days at Blomkest in 2020, and 28 days at Fargo in 2021. Data will not be included from Moorhead 2021 due to a combination of extremely dry conditions in May and poor sugarbeet emergence which compromised the quality of the experiment.

Table 4. Monthly rainfall totals in 2020 and 2021 and 30-yr averages, Blomkest and Moorhead, MN and Fargo, ND.[a]

	Blomkest, MN			Fargo, ND			Moorhead, MN		
Month	2020	2021	Avg.[b]	2020	2021	Avg.	2020	2021	Avg.
	--------	--------	--------	--------	Inch	--------	--------	--------	--------
April	1.6	1.8	2.6	4.5	1.5	1.3	5.4	2.3	1.6
May	2.1	1.4	3.1	1.5	0.9	2.8	1.6	0.7	3.2
June	4.9	1.3	4.8	3.5	3.3	4.1	3.8	4.6	4.1
July	3.9	1.7	3.7	5.9	0.9	2.8	5.3	0.9	3.2
August	4.5	5.0	3.8	5.8	3.9	2.6	5.8	3.7	2.7

[a]Data compiled from NOAA, Climate Corp, and/or NDAWN.
[b]Avg. = 30-year average.

Waterhemp control was influenced by ethofumesate rate and number of days after ethofumesate application at Moorhead and Blomkest (Figures 3 and 4). Waterhemp control from up to 7.5 pt/A of ethofumesate was less than 80% at Moorhead in 2020, regardless of receiving 0.6 inches of rain the day after application.

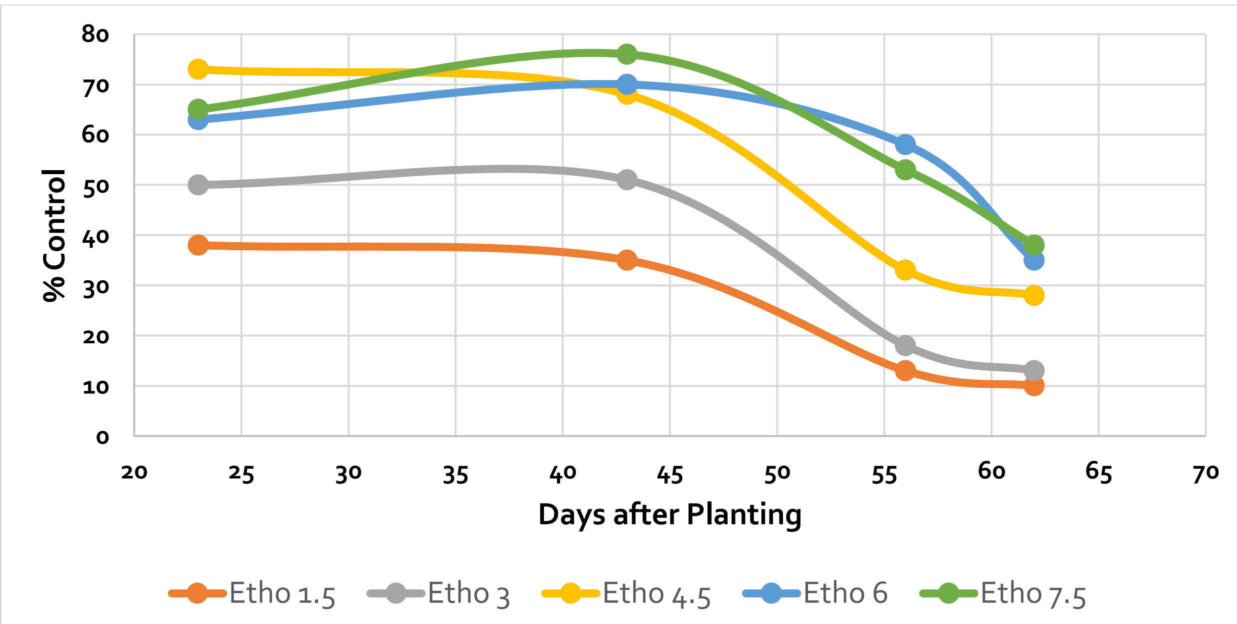

Figure 3. Visible waterhemp control 23 to 63 days after planting (DAP) in response to ethofumesate rate, Moorhead, MN, 2020.

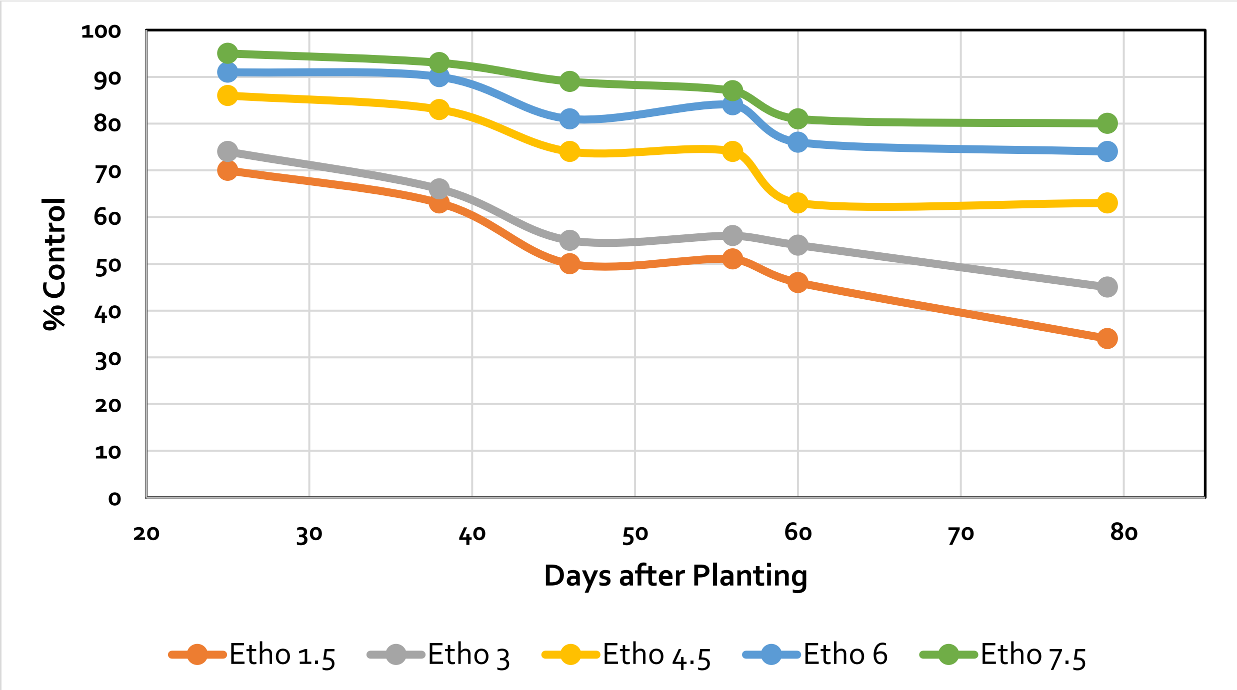

Figure 4. Visible waterhemp control 25 to 80 days after planting (DAP) in response to ethofumesate rate, Blomkest, MN, 2020.

Ethofumesate at 4.5, 6.0, and 7.5 pt/A provided up to 85% waterhemp control at Blomkest. However, ethofumesate at 1.5 and 3 pt/A provided less than 75% control. Waterhemp control results from Moorhead and Blomkest challenges the viability of ethofumesate PRE at 2 pt/A. Sub-lethal rates provide waterhemp control for a short duration or until an application of soil residual herbicides POST can be applied to sugarbeet. These data suggest sub-lethal rates are providing less than full waterhemp control, even for this short duration.

There were challenges in activating ethofumesate at the Fargo location in 2021, even with applying ethofumesate PPI. We observed differences in early and late germinating waterhemp control (Figure 5) based on application method. Ethofumesate applied PRE provided greater waterhemp control on early germinating waterhemp while ethofumesate applied PPI provided greater control on late germinating waterhemp.

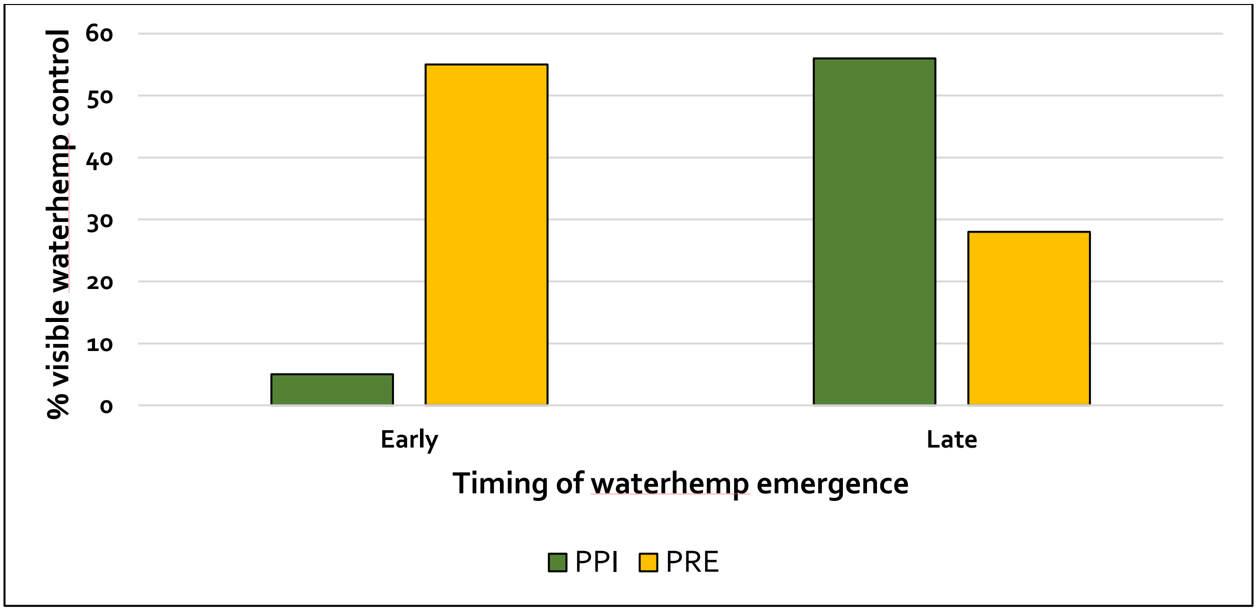

Figure 5. Early and late germinating waterhemp control in response to ethofumesate PPI and PRE, Fargo, 2021.

McAuliffe and Appleby (1984) reported ethofumesate tightly adsorbs to soil colloids and is susceptible to rapid degradation in dry soils. We believe some of the waterhemp control challenges we have observed in both our research and in commercial fields is related to chemical properties of ethofumesate as compared with chloroacetamide herbicides. For example, the ratio of herbicide bound to soil colloids (K_{OC}) versus herbicide in the soil solution is two-fold greater with ethofumesate than dimethenamid-P. In addition, dimethenamid-P water solubility is 10 times greater than ethofumesate. Although ethofumesate was incorporated after application in this study, its concentration was diluted by incorporation and tightly bound to soil colloids rendering it unavailable for waterhemp control. Control of late season waterhemp was improved since ethofumesate desorbed from soil and moved into the soil solution following rainfall events. In this experiment, ethofumesate PRE was partially incorporated into soil solution and made available for seedling uptake as a result of a 0.4-inch rainfall on May 10. The remaining ethofumesate PRE likely degraded and was unavailable for control of late emerging waterhemp, especially at the lower rates.

Waterhemp control with soil residual herbicides applied PRE and POST

A 0.8-inch rain event was measured on May 27 at Blomkest or 16 days after PRE application and 2 days after POST application to sugarbeet at the 2-lf stage (Table 5). A second 0.8-inch rainfall event was measured on June 28, or 18 days after 8-lf stage, 28 days after 4-lf stage, and 34 days after 2-lf stage application. Sugarbeet injury and waterhemp control were evaluated weekly between June 3 and July 15. Data collected June 12, June 25, and July 7 will be considered in this report. PRE treatment did not interact with POST treatment (Table 6). Thus, PRE treatment (no PRE, ethofumesate plus Dual Magnum, or ethofumesate) were averaged across POST treatment.

Sugarbeet visible growth reduction injury was evaluated 18 days after the 2-lf sugarbeet stage application. Sugarbeet injury from Warrant following Warrant or repeat Warrant applications following Outlook injured sugarbeet more than the untreated check treatment (Table 7). In addition, there were more incidents of greater than 30% sugarbeet injury in Warrant followed by Warrant or Outlook followed by Warrant followed by Warrant plots as compared with other POST treatments.

Table 5. Application information, Blomkest, MN 2021.

Date	May 11	May 25	June 1	June 10
Time of Day	9:40 AM	6:50 AM	12:40 PM	8:50 AM
Air Temperature (F)	53	70	73	82
Relative Humidity (%)	26	83	29	55
Wind Velocity (mph)	2	9	0	10
Wind Direction	W	S	-	SW
Soil Temp. (F at 6”)	47	66	67	75
Soil Moisture	Dry	Dry	Dry	Dry
Cloud Cover (%)	0	20	20	50
Sugarbeet Stage	PRE	2-lf	4-lf	8-lf
Waterhemp Height	-	0.5 inch	0.5 inch	1 inch

Table 6. Source of variation and P-values for sugarbeet injury and waterhemp control in response to treatment, Blomkest, MN, 2021.

	Sugarbeet Injury	Waterhemp Control		
Source of Variation	June 12	June 12	June 25	July 7
	--------------------------------*P-Value*----------------------------------			
Preemergence	0.0118	0.0917	0.0001	0.0001
Postemergence	0.0006	0.0001	0.0021	0.0001
Preemergence × Postemergence	0.9281	0.8540	0.6652	0.2340

Table 7. Sugarbeet visible injury, plots with 30% or greater injury, and visible waterhemp control from POST residual treatments averaged across PRE treatment, Blomkest, MN, 2021.[a]

		Sugarbeet Injury		Waterhemp Control		
Soil Residual Treatment POST[b]	Rate	18 DAT[c]		18 DAT[c]	31 DAT[c]	43 DAT[c]
	--pt/A--	--%--	--Num[d]--	------------------%------------------		
Untreated Check		8 bc	2	85 d	85 c	79 c
Outlook / Outlook	0.75 / 0.75	10 bc	3	95 ab	92 ab	88 ab
Warrant / Warrant	3 / 3	17 ab	12	86 d	89 bc	88 ab
Outlook / Warrant	0.75 / 3	8 bc	4	92 bcd	90 abc	89 ab
Outlook / Warrant	0.75 / 4	3 c	3	94 abc	91 abc	92 a
Outlook / Warrant / Warrant	0.75 / 3 / 3	22 a	14	99 a	96 a	95 a
LSD (0.10)		10		6	6	7

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including untreated check.
[c]Days after 2- to 4-lf stage application.
[d]Number of plots out of 24 with 30% or greater visible sugarbeet growth reduction injury.

Waterhemp control was greatest from Outlook at 18 days after 2-lf sugarbeet application. Outlook is more water soluble than Warrant and likely moved into the soil more efficiently with limited rainfall. Soil residual herbicide treatments applied EPOST, POST, and LPOST was activated from the June 28 rainfall event and provided waterhemp control greater than repeat Roundup PowerMax plus ethofumesate applications.

The Blomkest experiment received 1.8-inches total rainfall in May and June. Even under these drought conditions, chloroacetamide herbicides controlled waterhemp. Outlook at the 2-lf stage, averaged across PRE treatments, provided waterhemp control greater than Warrant at the 2-lf stage or repeat applications of Roundup PowerMax plus ethofumesate. However, chloroacetamide herbicides were equally as effective at controlling waterhemp 31 and 43 days after the 2-lf stage application. Outlook followed by repeat Warrant applications (totaling 3 POST treatments) provided greater numeric waterhemp control than 2-lf POST treatments, but injured sugarbeet more than the other POST treatments.

Postemergence treatment evaluations were averaged across PRE treatments (Table 8). Ethofumesate PRE at 6 pt/A and ethofumesate + Dual Magnum PRE at 2 pt + 0.5 pt/A, respectively, averaged across POST treatments had greater sugarbeet injury than no PRE. Preemergence treatments caused greater than 30% sugarbeet injury in more plots compared to no PRE when averaged across POST treatments. However, this sugarbeet injury is considered negligible. Preemergence treatments averaged across POST treatments controlled waterhemp greater than no PRE treatments, even in drought conditions.

Table 8. Sugarbeet visible injury, plots with 30% or greater injury, and visible waterhemp control from PRE treatments averaged across POST treatment, Blomkest, MN, 2021.[a]

		Sugarbeet Injury		Waterhemp Control		
Soil Residual treatment PRE[b]	Rate	32 DAP[c]		32 DAP	45 DAP	57 DAP
	--pt/A--	--%--	--Num[d]--	------------------%------------------		
None	-	7 b	8	89 b	85 b	83 b
Ethofumesate + Dual Magnum	2 + 0.5	13 a	18	93 a	91 a	89 a
Ethofumesate	6	15 a	20	92 a	94 a	91 a
LSD (0.10)		5		3	3	3

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAP = Days after planting.
[d]Num = Total number out of 56 plots with 30% or greater visible sugarbeet growth reduction injury.

The Moorhead experiment was planted into dry soil. The first 'herbicide incorporating' rain did not occur until June 7, 26 DAP or 6 days after the 2-lf sugarbeet stage application (Table 9). The Moorhead site received 4.6-inches total rainfall in June that activated soil residual herbicides. Waterhemp control data collected on June 27, July 17, and July 27 will be discussed in this report. Sugarbeet injury from herbicide treatments will not be presented as we observed stand challenges throughout the season. Preemergence treatments interacted with POST treatments for waterhemp control evaluations collected on June 27 and July 17 (Table 10). However, the interaction can largely be explained by waterhemp control from repeat applications of Roundup PowerMax plus ethofumesate with or without PRE herbicides. Thus, a discussion of PRE treatment (no PRE, ethofumesate plus Dual Magnum, or ethofumesate) averaged across POST treatments along with a discussion of POST applied soil residual herbicides averaged across PRE treatment will be emphasized in this report.

Table 9. Application information, Moorhead, MN 2021.

Date	May 12	June 1	June 9	June 22
Time of Day	5:00 PM	1:00 PM	9:00 AM	12:00 PM
Air Temperature (F)	75	77	80	75
Relative Humidity (%)	23	29	58	42
Wind Velocity (mph)	4	6	7	3
Wind Direction	S	SE	SE	S
Soil Temp. (F at 6")	60	66	70	70
Soil Moisture	Dry	Dry	Wet	Wet
Cloud Cover (%)	20	80	100	20
Sugarbeet Stage	PRE	2-lf	4-lf	8-lf
Waterhemp Height	-	0.5 inch	0.5 inch	1 inch

Table 10. Source of variation and P-values for waterhemp control in response to treatment, Moorhead, MN, 2021.

	Waterhemp Control		
Source of Variation	June 27	July 17	July 27
	------------------------------*P-value*------------------------------		
Preemergence	0.0002	0.0003	0.0007
Postemergence	0.0001	0.0001	0.0001
Preemergence × Postemergence	0.0566	0.0391	0.5459

Soil residual herbicides applied at the 2-, 4-, and 8-lf stage, averaged across PRE treatment, provided waterhemp control greater than repeat Roundup PowerMax plus ethofumesate applications (Table 11). Outlook followed by repeat Warrant applications tended to provide greater waterhemp control than other treatments as time progressed. However, sugarbeet injury tended to increase with this treatment at Blomkest. The benefit of soil residual herbicides increased from 26 to 47 days after the 2-lf stage application. Likewise, waterhemp control was greater from PRE treatments, averaged across POST treatments, as compared with no PRE treatment (Table 12).

Table 11. Visible waterhemp control from POST residual treatments averaged across all PRE treatments, Moorhead, MN, 2021.[a]

		Waterhemp Control		
Soil Residual Treatment POST[b]	Rate	26 DAT[c]	40 DAT	47 DAT
	--pt /A--	----------------------------%----------------------------		
None	-	76 c	49 c	31 d
Outlook / Outlook	0.75 / 0.75	96 a	89 a	84 ab
Warrant / Warrant	3 / 3	94 ab	89 a	81 b
Outlook / Warrant	0.75 / 3	95 ab	92 a	87 ab
Outlook / Warrant	0.75 / 4	98 a	91 a	89 ab
Outlook / Warrant / Warrant	0.75 / 3 / 3	98 a	95 a	93 a
LSD (0.10)		5	10	12

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAT = Days after 2- to 4-lf stage application.

Table 12. Visible waterhemp control from PRE treatments averaged across all POST treatments, Moorhead, MN, 2021.[a]

		Waterhemp Control		
Soil Residual Treatment PRE[b]	Rate	46 DAP[c]	66 DAP	76 DAP
	(pt /A)	-----------------------%-----------------------		
None	-	89 b	76 b	67 b
Ethofumesate + Dual Magnum	2 + 0.5	93 a	84 a	78 a
Ethofumesate	6	95 a	87 a	79 a
LSD (0.10)		3	5	6

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAP = Days after Plant.

Conclusion

Soil residual herbicides are the best strategy for waterhemp control in sugarbeet. We recommend producers follow the program and use soil residual herbicides PRE, EPOST, and POST to control waterhemp in sugarbeet, regardless of moisture conditions. Ethofumesate is often tank mixed with Dual Magnum (24c local needs label) PRE which enables some early season weed control in the event that ethofumesate is not incorporated into the soil by rainfall. Producers are considering greater ethofumesate rates along with pre-plant incorporation (PPI) at application. We recommend shallow incorporation (suitable to move ethofumesate into the surface 1-inch of soil) of ethofumesate and use rates greater than 3 pt/A to ensure ethofumesate is not diluted by incorporation. Finally, we recommend applying *S*-metolachlor (Dual Magnum, Brawl, Charger Basic, Medal, Mocassin, etc.), Outlook, or Warrant at the 2- to 4- and 6- to 8-lf stage. The idea of a third lay-by treatment (2-/4-/8-lf stage vs. 2- to 4- and 6- to 8-lf stage) tended to improve waterhemp control at Moorhead and Blomkest; however, increased sugarbeet injury at Blomkest.

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KOCHIA CONTROL IN SUGARBEET AND CROPS IN SEQUENCE WITH SUGARBEET

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Summary

1. Identify the weed challenges in your fields and prepare for sugarbeet by planting crops with effective weed control herbicides.
2. Kochia control in sugarbeet is greatest when Roundup PowerMax postemergence (POST) follows ethofumesate preemergence (PRE) applied at 6 or 7.5 pt/A or two or three applications of Roundup PowerMax + ethofumesate POST applied to kochia less than 3-inches tall during the season.
3. Kochia control from Ultra Blazer is inconsistent; likely due to kochia size at required Ultra Blazer application timing in sugarbeet.
4. Successful kochia control requires a program approach throughout the crop sequence, including sugarbeet production.

Introduction

Glyphosate-resistant (GR) kochia is reemerging as a weed control challenge for sugarbeet growers in Minnesota, North Dakota, and eastern Montana. Kochia is unique from other weed control threats in that there are few effective weed control options in sugarbeet. Kochia typically emerges in April and May, but some kochia biotypes emerge as late as June. Kochia is most severe when drought conditions reduce both sugarbeet stands and early season growth and development. Finally, kochia interferes with sugarbeet root yield by virtue of its rapid growth, resulting in sugarbeet suffocation due to enormous growth potential.

Herbicides are a major component of kochia control programs. The outcome of relying on herbicides, along with kochia's competitive characteristics and high genetic diversity, are population shifts and evolution of herbicide-resistant populations in many regions in Minnesota, North Dakota, and eastern Montana. Kochia has evolved resistance to at least four herbicide sites of action. They are (ALS) inhibitors, synthetic auxins, photosystem II (PSII) inhibitors, and EPSP synthase inhibitors or glyphosate, which are also herbicides effective for kochia control in crops in sequence with sugarbeet. Glyphosate-resistant kochia is widespread and concerning to farmers since glyphosate is relied upon in many cropping systems. The objectives of this research were to 1) evaluate non-glyphosate herbicide options in sugarbeet or crops grown in sequence with sugarbeet and; 2) provide kochia control options in Minnesota and North Dakota fields when corn, soybean, or wheat are seeded in sequence with sugarbeet.

Kochia control in crops in sequence with sugarbeet. Researchers from Colorado, Kansas, Nebraska, South Dakota, and Wyoming selected their favorite programs for kochia control in corn, soybean, sugarbeet, spring wheat and fallow in 2010 and 2011 (Sbatella et al., 2019). Overall, preferred programs were a combination of soil residual followed by (fb) POST herbicides applied singly or in repeat applications. Kochia control was arranged by crop and location across years (Figure 1). Herbicide programs approved for kochia control in corn or soybean demonstrated greater overall control with less variability across environments compared with fallow, wheat, and sugarbeet (Sbettala et al. 2019). The potential for a kochia control failure was relatively low in corn, regardless of the herbicide program evaluated, whereas in sugarbeet, there was no herbicide program evaluated that provided greater than 86% kochia control at any field location. The median kochia control was 40% in sugarbeet across all sites (Figure 1).

Effective, long-term kochia management in sugarbeet will likely depend on programs used within a crop rotation including corn, soybean, spring wheat, and spring barley. However, some kochia control herbicides create challenges as their crop rotation restrictions do not allow sugarbeet to be planted the following year. Corn, wheat, and to an extent, soybean, create dense canopies formed early in the growing season that compete with kochia. In contrast, sugarbeet is a poor competitor because of slow growth and development and relatively short stature.

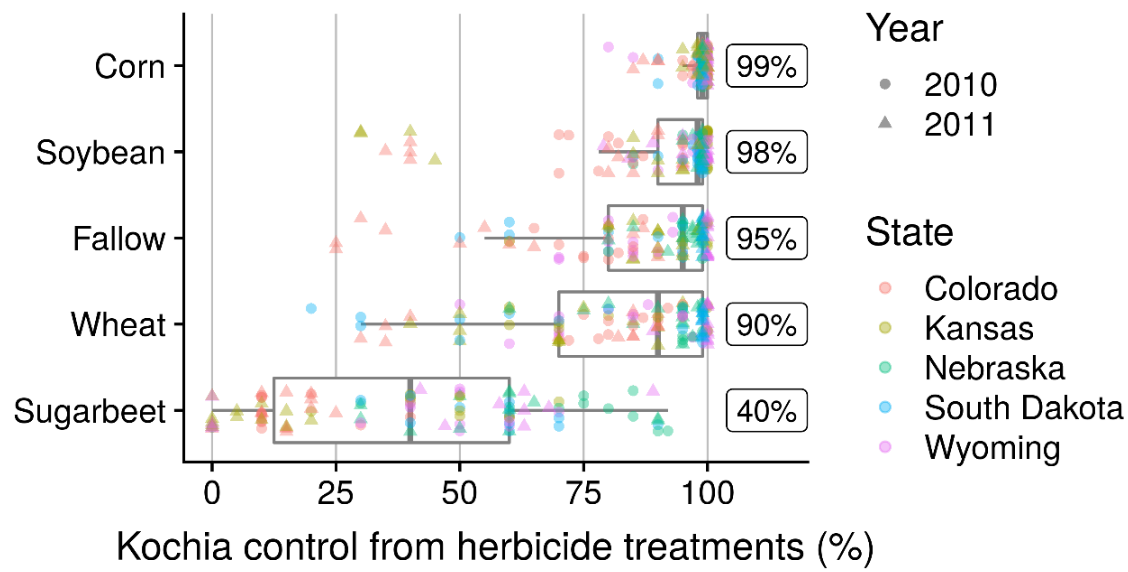

Figure 1. Kochia control, 30 days after final application of herbicide treatment, labeled for corn, soybean, fallow, wheat, and sugarbeet. Each point represents a plot in a field. Percentages are the median kochia control from herbicide treatments within each crop.

Eastern North Dakota and Minnesota. Dr. Joseph Ikley, North Dakota Extension Weed Control Specialist, lists his preferred kochia control programs in corn, soybean, and wheat. Recommendations are presented as product per acre. Please use the North Dakota Weed Control Guide to verify herbicide rates and crop rotation restrictions for soils and crop sequences on your farm.

1. Spring
   a. Corn
      i. Verdict (16-18 fl oz) + atrazine[1] (0.38 to 0.5 lb) or Harness MAXX (2 qt) + atrazine (0.38 to 0.5 lb) PRE fb PowerMax + Status (5 fl oz) POST (requires RR corn)
      ii. Acuron[2] (1.25 qt) or Acuron Flexi (1.25 qt) fb Acuron (1.25 qt) or Acuron Flexi (1.25 qt) + PowerMax (requires RR corn)
      iii. Capreno (3 fl oz) + PowerMax + atrazine (0.38 to 0.5 lb) EPOST (V2 to V4 corn, (less than 3-inch kochia) (requires RR Corn)
   b. Soybean
      i. Authority Edge[3] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend or XtendFlex soybeans, Liberty requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
      ii. Fierce MTZ[4] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
      iii. Authority MTZ[5] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans
   c. Spring Wheat
      i. Huskie FX[6] (full rate)
      ii. Starane NXT[7] (full rate)
      iii. Talinor[8] (full rate)

[1]Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[2]Acuron/Flexi requires an 18 month after application crop rotation restriction to sugarbeet.
[3] Authority Edge requires up to 36 months after application crop rotation restriction to sugarbeet.
[4] Fierce MTZ requires up to 18 months after application crop rotation restriction to sugarbeet.
[5] Authority MTZ requires up to 24 months after application crop rotation restriction to sugarbeet.
[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.
[7] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[8] Talinor requires a 15 month after application crop rotation restriction to sugarbeet.

Sidney Sugars, Western North Dakota and Eastern Montana. Kochia management in western North Dakota is complicated by irrigation practices on some acres. The following are a series of activities recommended by Dr. Brian Jenks for corn, soybean and wheat production in sequence with sugarbeet.

1. Fall. After fall ridging and before corn, soybean or spring wheat.
   a. Valor[1] at 3 oz/A after fall ridging
   b. We recommend no spring re-ridging since tillage will disturb the herbicide layer.
   c. Plan for fall Valor reducing spring kochia emergence 70%
1. Spring. Corn, soybean or small grains.
   a. Corn
      i. Verdict (10 fl oz minimum 15 fl oz is better) + atrazine[2] (0.38 lb) + AMS + MSO applied POST to emerged kochia and PRE to corn
      ii. Sharpen[3] (2-3 fl oz) + atrazine to reduce cost, applied POST to emerged kochia and PRE to corn
      iii. Roundup PowerMax + Status (5 fl oz) POST (requires RR corn). Glyphosate will get grasses but Verdict offers a different mode of action.
   b. Soybean
      i. Gramoxone or dicamba (XtendFlex soybeans are required) for burndown control of emerged kochia.
      ii. Fierce EZ[4] (full rate for soil type) fb Roundup PowerMax + dicamba or Liberty (dicamba or Liberty requires XtendFlex soybeans)
      iii. Fierce EZ may not get emerged kochia in spring burndown and twelve months may not be enough time to sugarbeet in dry conditions.
      iv. Liberty (requires Enlist, LibertyLink, LLGT27, or XtendFlex soybean) must be applied on less than 3-inch kochia and requires warm temperatures, sun, and humid conditions.
   c. Spring Wheat
      i. Gramoxone or a Gramoxone + Sharpen mix in the spring burndown.
      ii. Starane NXT[5] (full rate) or Huskie FX[6] (full rate) (the goal is to apply 1.5 to 2 oz/A fluroxypyr per acre)
      iii. Cleansweep D or Kochiavore (both have Starane + bromoxynil + 2,4-D). First choice is Huskie FX.

Kochia control in sugarbeet. Ethofumesate should be applied preplant incorporated (PPI) or PRE at 6 to 7.5 pt/A in sugarbeet fields when kochia, especially GR kochia, is a weed control challenge (Peters and Lueck 2016; Peters and Lystad 2021). Ethofumesate at less than 6 pt/A provided inconsistent kochia control, even when incorporated into the soil. Herbicide applications POST should be timed to kochia growth stage rather than sugarbeet growth stage. Kochia control POST is greatest in sugarbeet, even with glyphosate products, when it is less than 3-inches tall. The addition of Betamix improved kochia control from Roundup PowerMax + ethofumesate POST. However, Betamix rate must be carefully selected based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows soil applied (PPI or PRE) ethofumesate.

Material and Methods

Field experiments. Field experiments were conducted on natural kochia populations that were a mixture of glyphosate susceptible and glyphosate resistant biotypes near Horace, ND and Manvel, ND in 2021 (Table 1). Soil residual herbicides were applied before and after planting. The entire experimental area was tilled using a Kongskilde s-tyne cultivator with rolling baskets once preplant soil residual herbicides were applied to remove variability with tillage treatments. Sugarbeet was seeded in 22-inch rows at about 61,000 seeds per acre with 4.7 inch spacing between seeds. Treatments were applied with a bicycle sprayer through appropriate nozzles and CO_2 pressured to deliver 17 GPA spray solution to the center four rows of six row plots, 35 feet in length. Experiments were conducted to evaluate soil applied applications of ethofumesate PRE and POST applications of Betamix, Ultra Blazer, and ethofumesate rates and timings to maximize kochia control and minimize sugarbeet injury.

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[1] Valor requires up to 10 months after application crop rotation restriction to sugarbeet; tillage effects restriction.
[2] Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[3] Sharpen requires 5-6 months after application crop rotation restriction to sugarbeet (depending on rate used).
[4] Fierce EZ requires up to 12 months after application crop rotation restriction to sugarbeet.
[5] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.

Table 1. Herbicide treatment, rate, and application timing, Horace and Manvel ND, 2021.

Treatment	Rate (fl oz/A)	Kochia (inches)
Etho[1] / RU PowerMax[2]	64 / 28	PPI / 3
Etho / RU PowerMax	96 / 28	PPI / 3
Etho / RU PowerMax	120 / 28	PPI / 3
Etho / RU PowerMax	64 / 28	PRE / 3
Etho / RU PowerMax	96 / 28	PRE / 3
Etho / RU PowerMax	120 / 28	PRE / 3
Etho + RU PowerMax[3] / Etho + RU PoweMax	4 +28 / 4 + 28	1 / 3
Ultra Blazer[4]	16	3
Ultra Blazer + RU PowerMax + Etho	16 + 28 + 4	3

[1] etho = ethofumesate.

[2]Roundup PowerMax applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.

[3]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.

[4]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Visible sugarbeet growth reduction was evaluated using a 0% to 100% scale, (0 is no visible injury and 100 is complete loss of plant / stand) at the 2-lf sugarbeet stage and 7, 14, and 21 days after 2-lf stage application. Visual percent kochia control was evaluated using a 0% to 100% scale (0 is no control and 100 is complete control) at the 2-lf stage and 7, 14, 21 and 28 days after the 2-lf sugarbeet stage or when kochia was approximately 1-inch tall.

All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip. Experimental design was randomized complete block with four replications. Data was analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Greenhouse experiment. An experiment was conducted in the greenhouse to determine kochia control from Ultra Blazer. Kochia was grown in a flat containing a general-purpose greenhouse growing media (PRO-MIX BX, Quackertown, PA) and transplanted to 4 × 4-inch greenhouse pots. Herbicide treatments (Table 2) were applied when kochia reached 4-inches tall using a DeVries Generation III spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet 8001XR nozzle calibrated to deliver 10.5 GPA spray solution at 40 psi and 3 mph. Visual percent kochia control was evaluated using a 0% to 100% scale (0 is no control and 100 is complete control) 14 and 21 days after application (DAA). Data was analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing, greenhouse, 2021.

Treatment	Rate (fl oz /A)	Kochia (inches)
Ultra Blazer	16	4
Ultra Blazer + NIS	16 + 0.25% v/v	4
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.25% v/v	4
Untreated Control		4

Results and Discussion

Ethofumesate followed by Roundup PowerMax. A rain event to incorporate ethofumesate occurred 19 and 13 DAA at Horace and Manvel, respectively, in 2021. At Horace, kochia control was similar from Roundup PowerMax following ethofumesate averaged across rates and application method (Table 3). At Manvel, kochia control tended to be greater from Roundup PowerMax following ethofumesate applied PRE and average across rates as compared with kochia control from Roundup PowerMax following ethofumesate applied PPI. Incorporation moves ethofumesate into the soil. However, caution must be taken to ensure incorporation does not move ethofumesate too deep into the soil. Kochia control across locations tended to increase when ethofumesate was applied at 6 or 7.5 pt/A as compared with kochia control from ethofumesate at 4 pt/A. Kochia population was glyphosate-susceptible at both sites, so there were only modest differences across treatments following glyphosate application. Kochia control is greatest in sugarbeet when Roundup PowerMax follows ethofumesate and is applied to small kochia escapes or when Roundup PowerMax alone (not presented) or tank mixed ethofumesate is repeated three times during the growing season, beginning when kochia is less than 3-inches tall.

Table 3. Visible kochia control in response to herbicide treatment, Horace and Manvel ND, 2021.[1]

		Kochia Control			
		Horace		Manvel	
Treatment	Rate	28 DAT	42 DAT	7 DAT	21 DAT
	---fl oz/A---	---------------------------%-------------------------			
Etho[2] / RU PowerMax[3]	64 / 28	85 b	70 d	73 b	78 abc
Etho / RU PowerMax	96 / 28	90 ab	83 bc	73 b	79 abc
Etho / RU PowerMax	120 / 28	97 a	94 a	80 ab	82 ab
Etho / RU PowerMax	64 / 28	86 b	73 cd	93 a	92 a
Etho / RU PowerMax	96 / 28	94 a	88 ab	80 ab	86 ab
Etho / RU PowerMax	120 / 28	92 ab	76 cd	88 ab	94 a
Etho + RU PowerMax[4] / Etho + RU PowerMax	4 +28 / 4 + 28	85 b	70 d	85 ab	75 bc
Ultra Blazer[5]	16	25 c	10 e	50 c	32 d
Ultra Blazer + RU PowerMax + Etho	16 + 28 + 4	91 ab	73 cd	80 ab	66 c
LSD (0.10)		**8**	**11**	**16**	**13**

[1]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[2]etho = ethofumesate.
[3]Roundup PowerMax applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.
[4]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[5]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Kochia control with Ultra Blazer. Kochia control from Ultra Blazer across locations and years has been inconsistent (Table 4). Some of the inconsistency is attributed to kochia size at application since Ultra Blazer application must be timed to sugarbeet growth stage. Ultra Blazer application for control of glyphosate-resistant kochia must be used in a program approach with products providing partial kochia control.

Table 4. Visible kochia control in response to herbicide treatment, Horace and Manvel ND, 2020 and 2021.[1]

		Horace		Manvel	
Treatment[2]	Rate	2020	2021	2020	2021
	---fl oz/A---	-------------------------%-------------------------			
Ethofumesate PRE / RU PowerMax	120 / 28	75 a	92 a	80 b	94 a
Ultra Blazer	16	25 b	25 b	83 b	33 c
Ultra Blazer + RU PowerMax	16 + 28	86 a	91 a	96 a	66 b
LSD (0.10)		**10**	**8**	**11**	**13**

[1]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[2]All POST treatments applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.

Ultra Blazer plus Roundup PowerMax with AMS and NIS improved visible kochia control compared with Ultra Blazer alone (Table 4, Table 5) and tended to provide greater fresh weight reduction compared with Ultra Blazer alone with or without NIS (Table 5). The greenhouse experiment was a two-replication demonstration experiment, so the results were variable. Kochia control was less 21 DAA as compared with 10 DAA, due to incomplete kochia kill and regrowth following herbicide treatment.

Table 5. Visible kochia control and kochia fresh weight reduction in response to herbicide treatment, 10, 18, and 21 DAT, greenhouse, 2021.[1]

Treatment	Rate	Visible Kochia Control		Fresh Weight Reduction
		10 DAT	18 DAT	21 DAT
	--fl oz /A--	---------------------%-------------------------		
Ultra Blazer	16	55 a	30 c	23 b
Ultra Blazer + NIS	16 + 0.25% v/v	55 a	55 b	37 ab
Ultra Blazer + RU PowerMax + AMS + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	78 a	80 a	68 a
Untreated Control	-	0 b	0 d	-
LSD (0.20)		**22**	**15**	**41**

[1]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.

Kochia was grown up to 4-inches tall before application in the greenhouse to ensure treatment differences. Previous research, along with our own field observations, reinforce the importance of kochia size at Ultra Blazer application. Wicks (Wicks et al. 1997) reported kochia control was dependent on size at Ultra Blazer application (Figure 2). In general, their results suggest kochia size should be less than 2-inches to achieve 60% or greater kochia control at 32 fl oz/A. Ultra Blazer at 16 fl oz/A is the maximum rate in sugarbeet.

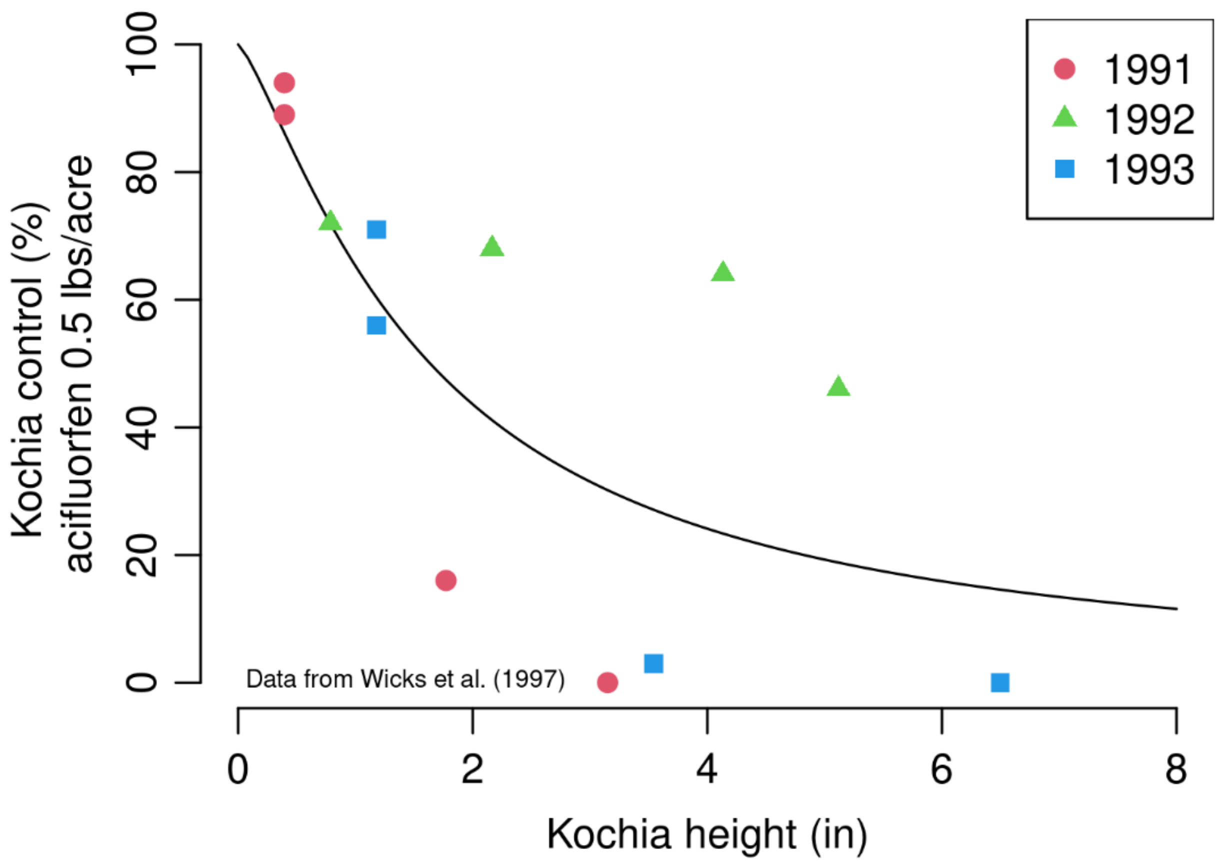

Figure 2. Visible kochia control (%) in response to Ultra Blazer at 2 pt/A at various kochia height (in), 1991, 1992, and 1993. Figure adapted by Kniss using data from Wicks et al. 1997.

Recommendations in sugarbeet

Eastern North Dakota and Minnesota. Ethofumesate at 6 pt/A or greater followed by glyphosate alone or repeat glyphosate plus ethofumesate applications, beginning when kochia is less than 3-inches tall, provides the greatest kochia control in sugarbeet. At this point, we do not have sufficient information to support kochia control in sugarbeet with Ultra Blazer or Ultra Blazer plus glyphosate.

Sidney Sugars, Recommendations in Sugarbeet. The biotype in western North Dakota appears to be resistant, or glyphosate control is influenced by environmental conditions at application. We recommend spraying small kochia with full glyphosate rates and adjuvants. We recommend a program approach including ethofumesate (fall or spring applied) followed by glyphosate. At this point, we do not have data to support Ultra Blazer use in sugarbeet in Williams or McKenzie counties in North Dakota or eastern Montana.

1. Fall. After fall ridging and before sugarbeet.
    a. Ethofumesate (Nortron, Ethotron, Nektron, or Ethofumesate 4SC) at 4 to 6 pt/A depending on organic matter (OM) and soil texture.
    b. Up to 3 pt/A if spring ethofumesate application follows fall application. We recommend no spring re-ridging since tillage will disturb the herbicide layer.
2. Spring. Sugarbeet plant.
    a. Ethofumesate PRE at 3 to 6 pt/A depending on OM and soil texture.
        i. Apply ethofumesate as early as possible to, and in advance of, spring rains.
    b. Glyphosate plus ethofumesate, POST. A total of 12 fl oz/A ethofumesate can be applied in sugarbeet.
        i. Use full rates of glyphosate products with adjuvants depending on formulation.
        ii. Apply to 3-inches or less kochia with water volumes to achieve good coverage.

Acknowledgements

We wish to thank Mr. Scott Johnson, Manvel, ND, for his collaboration with field research in 2020 and 2021.

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SPRING WHEAT TOLERANCE TO ETHOFUMESATE APPLIED THE PREVIOUS YEAR IN SUGARBEET

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Summary

1. This experiment was a continuation from Experiment 1 described in "Waterhemp Control in 2020" in the 2020 Sugarbeet Research and Extension Reports.

2. Ethofumesate rate did not influence spring wheat emergence. Spring wheat growth reduction injury was negligible from ethofumesate PRE at 1.5 pt/A to 7.5 pt/A applied the previous season.

Introduction

Ethofumesate is one of our most flexible herbicides in sugarbeet and is used at rates ranging from 0.25 to 7.5 pint per acre for control of pigweed species including waterhemp. A common question from sugarbeet producers relates to the number of weeks of weed control provided by ethofumesate at various rates. For others, questions about ethofumesate safety to spring wheat or barley as a nurse crop are concerns.

Ethofumesate (a group 16 herbicide) binds stronger to soil colloids, is less water soluble, and has a half-life greater than group 15 herbicides used in sugarbeet. Thus, sugarbeet producers have concerns about ethofumesate carryover from sugarbeet to crops in sequence with sugarbeet including spring wheat and corn. Lystad, Peters, and Sprague reported ethofumesate does not injure corn, dry bean, soybean, and wheat when applied at labeled rates 9-, 10- or 11-months before rotation crop planting (Journal of Sugarbeet Research, 2020). Schroeder and Dexter (1978) and Schweizer (1977) reported ethofumesate carryover is greatest under dry environmental conditions or when little or no tillage follows sugarbeet in preparation for wheat.

Objective

Our objectives spanned over two growing seasons. The first objective was to determine how many weeks of waterhemp control can be expected from ethofumesate preemergence (PRE). The second objective determined spring wheat injury from ethofumesate PRE at 1.5 to 7.5 pt/A in 2020.

Material and Methods

2020 Experiment

Experiments were conducted on natural weed populations near Moorhead, MN and Blomkest, MN to evaluate waterhemp control and wheat nurse-crop tolerance to ethofumesate PRE at multiple rates in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Spring wheat at 0.75 bu/A was uniformly spread across the experimental area and incorporated with shallow tillage before ethofumesate application. Sugarbeet was seeded in rows spaced 22 inches apart at approximately 62,000 seeds/A or approximately 4.6 inch spacing between seeds within the row in the experiment at Blomkest, MN but sugarbeet was not planted in the experiment at Moorhead, MN.

Herbicide treatments were applied PRE after planting with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center 6.67 feet of the 11 by 40 feet long plots. Treatments consisted of one application of ethofumesate at 0, 1.5, 3.0, 4.5, 6.0 and 7.5 pt/A.

Wheat injury and waterhemp control were evaluated visually, beginning approximately twenty-three days after ethofumesate application (DAA). Additional waterhemp control was evaluated 43, 56, and 62 days after planting (DAP) at Moorhead and 36, 44, 58, and 77 DAP at Blomkest. All evaluations were a visual estimate of control in the treated area compared to the adjacent untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

2021 Experiment
The 2020 experiment was continued near Moorhead, MN in 2021 to determine spring wheat tolerance in the year following PRE ethofumesate application. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Spring wheat at 0.75 bu/A was evenly spread throughout the plot area and incorporated with shallow tillage. Tillage was applied in the same direction as the previous herbicide treatments. Experimental area was maintained weed-free to evaluate spring wheat growth.

Evaluations considering the number of days for spring wheat to emerge and visible assessment of wheat safety in the treated area (0% to 100% injury, 0% indicating no wheat injury and 100% indicating complete loss of wheat stand) compared with the adjacent untreated strip were collected 7, 14, and 21 days after wheat emergence. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Results
For results regarding the 2020 experiment, please reference "Waterhemp control in 2020" in the 2020 Sugarbeet Research and Extension Reports. Spring wheat did not immediately germinate and emerge following May planting due to extremely dry conditions. We did not observe spring wheat emergence until mid-June or after June 7 and June 10 when the site received 0.7- and 1.4-inch rainfall, respectively. Ethofumesate rate did not delay emergence and spring wheat injury was negligible (Table 1). A trend of increased ethofumesate rate translated to increased growth reduction; however, the greatest growth reduction measured was 15%.

Table 1. Spring wheat growth reduction in response to ethofumesate rate applied PRE in 2020 at Moorhead, MN in 2021.

Ethofumesate Rate	17 DAE[1]	22 DAE	30 DAE
--pt/A--	-----------------------------% growth reduction---------------------------		
0	0 a	0	0
1.5	0 a	5	0
3	11 ab	10	8
4.5	5 ab	5	0
6	6 ab	8	0
7.5	15 b	13	0
LSD (0.20)	12	NS	NS

[1]DAE=Days after emergence.

Conclusion
Carryover to spring wheat was negligible from ethofumesate application from 1.5 pt/A to 7.5 pt/A to sugarbeet the previous season. There were no differences observed in spring wheat growth by 22 days after emergence.

References

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SUGARBEET TOLERANCE FOLLOWING HERBICES FOR WATERHEMP CONTROL IN SMALL GRAIN STUBBLE

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Summary

Introduction
Small grains are effective crops to control waterhemp since they become established before waterhemp germination and emergence. However, waterhemp may begin to grow and produce seed following small grain harvest in late July and August.

Postemergence herbicides were applied alone or in mixtures for waterhemp control in wheat stubble in 2020. Sharpen and Valor (PPO inhibitors, group 14) require 4-month rotation restriction to sugarbeet (4-month unfrozen ground) and 4-month rotation restriction and tillage, respectively, to sugarbeet. Valor can carry over to sugarbeet planted in sequence with soybean, especially when soybean is planted in late May or June or in course textured soils or soils with low organic matter. A rotational crop experiment was seeded in 2021 to determine if fall-applied Valor or Sharpen injured sugarbeet planted the following May.

Objective
The objective of this experiment was to evaluate sugarbeet tolerance following fall-applied herbicides to control waterhemp in small grain stubble.

Material and Methods
2020
An experiment was conducted in wheat stubble on natural waterhemp populations near Moorhead, MN in 2020. Experimental area consisted of a uniform infestation of waterhemp ranging from newly emerged to 12 inches tall.

Herbicide treatments were applied on August 20 and September 2, 2020 with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 43 psi. The treatment list can be found in Table 1.

Table 1. Herbicide treatments and rates in trial near Moorhead, MN in fall of 2020.

Herbicide Treatment	Rate (fl oz/A)
Roundup PowerMax[1]	32
Roundup PowerMax + Weedar 64[1]	32 + 64
Roundup PowerMax + Sharpen[2]	32 + 1
Roundup PowerMax + Sharpen[2]	32 + 2
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 1
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 2
Roundup PowerMax / Roundup PowerMax[1]	32 / 32
Roundup PowerMax + Weedar 64 /	32 + 64 /
Roundup PowerMax + Weedar 64[1]	32 + 64

[1]Treatment applied with Prefer 90 NIS at 0.25 % v/v + N-Pak Liquid AMS at 2.5% v/v.
[2]Sharpen and Valor SX applied with methylated seed oil at 1.5 pt/A + N-Pak Liquid AMS at 2.5% v/v.

Fall chisel plow tillage was done parallel with fall applied treatments so that herbicide would not be carried across plots. The corners of the experimental area were marked so that plots could be located again in 2021.

2021
The experimental area was prepared for planting by applying the appropriate fertilizer. Spring tillage was with a Kongskilde s-tine field cultivator with rolling baskets and was done parallel to 2021 treatments so that soil would not be carried between plots. Sugarbeet was seeded on May 12, 2021 in 22-inch rows at about 62,000 seeds per acre

with 4.6 inch spacing between seeds. Inadequate spring rainfall lead to poor sugarbeet stands. We opted to replant on June 16, 2021 and had excellent stands since planting was timed to moisture both before and after replant.

Sugarbeet stands were counted and sugarbeet visible injury was evaluated 7, 14, and 21 days after planting (DAP). Evaluations were a visual estimate of injury 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 with the ANOVA procedure of ARM, version 2021.2 software package.

Results

Sugarbeet stand (number of sugarbeet per 100 ft row) were similar across treatments and sugarbeet injury was negligible across treatments and evaluation (Table 2). Sugarbeet stand and injury differences did not relate to fall applied treatments.

Table 2. Percent visual sugarbeet injury by treatment and evaluation date near Moorhead, MN in 2021.

		Sugarbeet	Sugarbeet Injury		
Treatment	Rate	Stand	16 DAP[3]	24 DAP	30 DAP
	--fl oz/A--	Num/100 ft	-------------------%-------------------		
Roundup PowerMax[1]	32	135	0	0	5
Roundup PowerMax + Weedar 64[1]	32 + 64	123	0	0	0
Roundup PowerMax + Sharpen[2]	32 + 1	126	8	8	10
Roundup PowerMax + Sharpen[2]	32 + 2	144	6	5	0
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 1	134	8	13	10
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 2	124	5	15	5
Roundup PowerMax / Roundup PowerMax[1]	32 / 32	110	10	10	5
Roundup PowerMax + Weedar 64 / Roundup PowerMax + Weedar 64[1]	32 + 64 / 32 + 64	131	3	0	5
LSD (0.05)			**NS**	**NS**	**NS**

[1]Treatment applied with Prefer 90 NIS at 0.25 % v/v + N-Pak Liquid AMS at 2.5% v/v.
[2]Sharpen and Valor SX applied with methylated seed oil at 1.5 pt/A + N-Pak Liquid AMS at 2.5% v/v.
[3]DAP=Days after planting.

Conclusion

The experiment did not detect carryover from Sharpen or Valor. However, Valor and Sharpen carryover is an interaction depending on soil type and organic matter, herbicide rate, timing between application and sugarbeet plant, and rainfall and temperature conditions. Because of this, occasionally, we observe significant sugarbeet injury, even though none was observed in this study.

SUGARBEET TOLERANCE AND WATERHEMP CONTROL FROM ULTRA BLAZER IN A WEED MANAGEMENT PROGRAM

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Summary

1. Ultra Blazer (acifluorfen) must be applied alone or with glyphosate postemergence (POST) at the 6 leaf sugarbeet stage or greater.
2. Preemergence (PRE) applications did not affect sugarbeet injury, root yield, % sucrose, or recoverable sucrose from Roundup PowerMax, ethofumesate, Ultra Blazer and/or Dual Magnum.
3. Ultra Blazer in a waterhemp management program caused significant sugarbeet injury and reduced root yield and recoverable sucrose compared with Roundup PowerMax and Dual Magnum and/or ethofumesate.
4. Ultra Blazer is best used as a tool to control escaped waterhemp; NOT as part of a weed control program.
5. Waterhemp control results support Ultra Blazer application to control waterhemp escapes.

Introduction

Sugarbeet tolerance and waterhemp control from POST Ultra Blazer applications were investigated in 2019 and 2020. Two conclusions of this research were realized. First, Ultra Blazer applied at 16 fl oz/A should be timed to 6 leaf or greater sugarbeet. Ultra Blazer applied before the 6 leaf sugarbeet stage causes necrosis and stature reduction that reduces root yield and recoverable sucrose. Second, sugarbeet tolerance or waterhemp control from Ultra Blazer is influenced by adjuvant type and herbicide mixture with Ultra Blazer. We observed greater waterhemp control from Ultra Blazer mixtures with Roundup PowerMax, Stinger, and/or ethofumesate than from these herbicides applied individually. Previous research indicates Ultra Blazer postemergence provides effective control of other broadleaf weeds including kochia, redroot pigweed, palmer amaranth, and Pennsylvania smartweed.

Ultra Blazer may fit best in a weed management program with glyphosate, ethofumesate, and a chloroacetamide herbicide timed at the 6-lf sugarbeet stage or mixed with glyphosate and timed to the 8- to 12-lf stage. 2021 experiments were directed to explore both tolerance and weed control from Ultra Blazer as either a component in a weed management program or a treatment to control escape waterhemp.

Objectives

2021 objectives are a) determine if sugarbeet tolerate Ultra Blazer when applied in a waterhemp control program with Roundup PowerMax, ethofumesate, and Dual Magnum at the 6-lf sugarbeet stage; and b) evaluate sugarbeet tolerance and waterhemp control from Ultra Blazer mixtures with Roundup PowerMax, ethofumesate, Dual Magnum, and/or Stinger at the 6- to 8-lf sugarbeet stage.

Materials and Methods

Sugarbeet Tolerance

Experiments conducted in 2021 near Crookston, Hendrum, Norcross, and Murdock, MN evaluated sugarbeet tolerance from Ultra Blazer as a component in the waterhemp management program. 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. 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 40 psi to the center four rows of six row plots 40 feet in length.

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. All evaluations were a visual estimate of injury in the four treated rows compared to the adjacent, two-row, untreated strip. At harvest, sugarbeet was defoliated, harvested mechanically from the center two rows of each plot, and weighed. A sugarbeet 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 in a factorial treatment arrangement with factors being preemergence and postemergence herbicide. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Herbicide treatment, rate, and application timing, sugarbeet tolerance.

Factor A PRE Herbicide	Factor B Postemergence Herbicide	Rate (fl oz/A)	Sugarbeet stage (lf)
No	Roundup PowerMax[a] + etho[b] / Roundup PowerMax + etho	28 + 6 / 28 + 6	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	2 / 6-8
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[c]	28 + 6 / 28 + 16	2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax[a] + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 2 + 6 + 16 / 28 + 6 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	PRE / 2 / 6-8

[a]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[b]etho = ethofumesate.
[c]Ultra Blazer applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Ultra Blazer Efficacy

Efficacy experiments were conducted on natural populations of waterhemp in sugarbeet grower fields near Moorhead, Glyndon, and Blomkest, MN in 2021. We elected not to include the Moorhead site in this summary due to poor early season sugarbeet development. All treatments (Table 2) were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length.

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Weed control was also evaluated as percent biomass reduction. All evaluations were a visual estimate of injury or control in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was a randomized complete block design with four replications in a factorial treatment arrangement with factors being preemergence and postemergence herbicides. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing, sugarbeet efficacy.

Factor A PRE Herbicide	Factor B POST Herbicide	Rate (fl oz /A)	Sugarbeet stage (lf)
No	Roundup PowerMax[a] + etho[b] / Roundup PowerMax + etho	28 + 6 / 28 + 6	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	2 / 6-8
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[c]	28 + 6 / 28 + 16	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 +6 / 28 + 6	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	38 + 32 / 28 + 6 + 16 / 28 + 6 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	PRE / 2 / 6-8

[a]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[b]etho = ethofumesate.
[c]Ultra Blazer applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Results

Sugarbeet Tolerance

Sugarbeet injury, root yield, % sucrose, and recoverable sucrose from herbicide treatments applied POST were not affected by PRE treatment (Tables 3 and 4). Sugarbeet injury occurred 7 and 14 days after treatment (DAT) from Roundup PowerMax plus ethofumesate and Dual Magnum as well as Roundup PowerMax plus Ultra Blazer and Dual Magnum compared with Roundup PowerMax plus ethofumesate alone; however, sugarbeet injury from Roundup PowerMax plus ethofumesate and Dual Magnum was the same as Roundup PowerMax plus ethofumesate alone by 21 DAT. Sugarbeet injury at 7, 14, and 21 DAT was always greater when Ultra Blazer was mixed with Roundup PowerMax and Dual Magnum.

Treatments containing Ultra Blazer reduced root yield and recoverable sucrose as compared with Roundup PowerMax plus ethofumesate or Roundup PowerMax plus ethofumesate and Dual Magnum (Table 4). However, sucrose content was not affected by Ultra Blazer. These results indicate that Ultra Blazer applied as part of a weed management program reduces sugarbeet stature, root yield, and recoverable sucrose.

Table 3. Sugarbeet injury of necrosis and growth reduction in response to herbicide treatment, averaged across four locations, 2021.[a]

PRE Herbicide	POST Herbicide	Rate	Sugarbeet Injury 7 DAT[b]	14 DAT	21 DAT
		----fl oz /A----	---------------%----------------		
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	3 a	2 a	3 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	16 + 6 + 28 / 16 + 6 + 28	11 bc	9 b	6 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	44 d	42 c	32 b
Etho+Dual Magnum	Roundup PowerMax + etho / Roundup PowerMax + etho	32 + 8 / 28 + 6 / 28 + 6	4 ab	1 a	2 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 6 + 16	13 c	8 b	7 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 16 + 16	50 d	43 c	35 b
P-Value			**<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]DAT = days after treatment.
[c]etho = ethofumesate.

Table 4. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across four locations, 2021.[a]

PRE Herbicide	POST Herbicide	Rate	Root Yield	Sucrose	Recoverable Sucrose
		----fl oz/A----	-Ton/A-	--%--	---lb/A---
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	38 a	15.9	10, 423 a
No	Roundup PowerMax + etho + Dual Magnum[d] / Roundup PowerMax + etho + Dual Magnum	16 + 6 + 28 / 16 + 6 + 28	36 a	15.8	10, 040 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	32 b	15.5	8,713 b
Etho+Dual Magnum	Roundup PowerMax + etho / Roundup PowerMax + etho	32 + 8 / 28 + 6 / 28 + 6	38 a	15.7	10, 223 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 6 + 16	37 a	15.7	10, 141 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 16 + 16	32 b	15.6	8, 507 b
P-Value			**<0.0001**	**0.2402**	**<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]DAT = days after treatment.
[c]etho = ethofumesate.

Ultra Blazer Efficacy

The experiment at Moorhead, MN had poor stands and sporadic weeds, especially early in the growing season. Due to variability, discussion will focus on results from Blomkest and Glyndon experiments.

Sugarbeet injury at Glyndon was greater than Blomkest (Table 5). Daily maximum air temperature was 75°F and 82°F on May 31 and June 1, respectively, but increased to greater than 90°F on June 3, the date of the POST application at Glyndon. Daily maximum air temperatures averaged above 90°F through June 10 at Glyndon, MN which likely contributed to sugarbeet injury. Sugarbeet injury was not limited to only treatments containing Ultra Blazer. Multiple applications of Roundup PowerMax plus ethofumesate and Dual Magnum at the 2- and 6-lf stage caused more injury than Roundup PowerMax plus ethofumesate at the 2-lf stage followed by Roundup PowerMax plus ethofumesate at the 6-lf stage.

Table 5. Sugarbeet injury from tank mixtures with Ultra Blazer, 14 DAT, Glyndon and Blomkest, MN, 2021.[a]

PRE Herbicide	POST Herbicide[b]	Rate	Sugarbeet Injury Glyndon	Sugarbeet Injury Blomkest
		--fl oz/A--	--------%--------	
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	0 d	4 c
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	15 cd	8 c
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[d]	28 + 6 / 28 + 16	72 ab	33 b
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	84 a	43 ab
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	86 a	45 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	12 d	0 c
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 28 + 6 + 16 / 28 + 6 + 16	29 c	6 c
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	64 b	35 b
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	86 a	41 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	86 a	49 a
LSD (0.10)			**16**	**13**

[a]Means within location not sharing any letters are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[c]etho = ethofumesate.
[d]Ultra Blazer treatments applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

Sugarbeet injury from treatments containing Ultra Blazer were greater than treatments containing Roundup PowerMax, ethofumesate, and/or Dual Magnum at Blomkest. However, injury was similar among treatments containing Roundup PowerMax, ethofumesate, and Dual Magnum. The addition of Stinger to Roundup PowerMax plus Ultra Blazer and Dual Magnum did not increase sugarbeet injury as compared with Roundup PowerMax plus Ultra Blazer and Dual Magnum alone. PRE herbicide did not affect sugarbeet injury.

Ultra Blazer improved waterhemp control compared with Roundup PowerMax plus ethofumesate alone or Roundup PowerMax mixtures with ethofumesate and Dual Magnum at Blomkest, but only improved waterhemp control compared with Roundup PowerMax plus ethofumesate in the absence of a PRE at Glyndon (Table 6). Blomkest was much drier than Glyndon, especially in April and May. Similar waterhemp control was observed from Ultra Blazer mixtures with Roundup PowerMax or Ultra Blazer mixtures with Roundup PowerMax and Dual Magnum at both locations. Waterhemp control was numerically greatest when Ultra Blazer was mixed with Roundup PowerMax, Dual Magnum, and Stinger. However, this treatment also caused the most sugarbeet injury at Blomkest (Table 5). Waterhemp control results support Ultra Blazer applied POST to control waterhemp escapes.

Glyphosate provided excellent common lambsquarters control at Glyndon and Blomkest (data not presented).

Table 6. Waterhemp control from tank mixtures with Ultra Blazer, 14 DAT, Blomkest and Glyndon, MN, 2021.[a]

			Waterhemp Control	
PRE Herbicide	**Postemergence Herbicide[b]**	**Rate**	**Glyndon**	**Blomkest**
		--fl oz/A--	---------%---------	
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	85 b	65 e
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	94 ab	69 de
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[d]	28 + 6 / 28 + 16	90 ab	90 ab
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	98 a	94 a
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	99 a	93 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	93 ab	83 bc
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 28 + 6 + 16 / 28 + 6 + 16	99 a	78 cd
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	96 ab	94 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	98 a	95 a
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	99 a	98 a
LSD (0.10)			**12**	**11**

[a]Means within a location not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[c]etho = ethofumesate.
[d]Ultra Blazer treatments applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

Conclusion

Ultra Blazer applied with Roundup PowerMax and Dual Magnum increased visual sugarbeet injury and reduced root yield and recoverable sucrose as compared with Roundup PowerMax plus ethofumesate alone or in mixtures with Dual Magnum. Thus, we strongly discourage UPL or agriculturalists from recommending the tank mix of Ultra Blazer with Roundup PowerMax and Dual Magnum. Dual Magnum was the only chloroacetamide used in this experiment and it is possible the results may not translate to mixtures with Outlook or Warrant. However, our research indicates sugarbeet injury increases when oil-based formulations are mixed with Ultra Blazer.

These experiments support Ultra Blazer application to control waterhemp escapes. Ultra Blazer has been shown most effective on waterhemp less than 2-inches tall. Ultra Blazer improved waterhemp control compared with Roundup PowerMax plus ethofumesate alone and improved control from Roundup PowerMax mixtures with ethofumesate and Dual Magnum in an environment where rainfall to incorporate soil residual herbicides was lacking. Waterhemp control numerically was greatest when Ultra Blazer was mixed with Roundup PowerMax, Dual

Magnum, and Stinger. However, this treatment caused the most sugarbeet injury at Blomkest. Waterhemp control results support Ultra Blazer application to control waterhemp escapes.

SUGARBEET TOLERANCE AND WATERHMP CONTROL FROM ULTRA BLAZER ALONE AND IN MIXTURES WITH ROUNDUP POWERMAX AND STIMTIDE

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Summary

1. Stimtide is marketed to improve plant growth and may aid in plant recovery from pesticide damage.
2. Sugarbeet necrosis and growth reduction injury was decreased and fresh weight was increased when Stimtide was mixed with Ultra Blazer as compared with Ultra Blazer alone.
3. Stimtide did not reduce injurious affects from mixtures of Roundup PowerMax and Ultra Blazer.
4. Stimtide mixed with Ultra Blazer and non-ionic surfactant reduced waterhemp control and tended to increase waterhemp fresh weight.
5. We must reject our hypothesis since Stimtide safened sugarbeet injury from Ultra Blazer and non-ionic surfactant but also reduced waterhemp control.

Introduction

Sugarbeet growers applied Ultra Blazer alone or Ultra Blazer mixtures with Roundup PowerMax for waterhemp control using a Section 18 emergency exemption in sugarbeet in 2021. Necrosis injury from Ultra Blazer was greater when Ultra Blazer was mixed with oil-based adjuvants, application applied in the morning on days with day-time maximum air temperatures greater than 90F, and/or Ultra Blazer was mixed with Roundup PowerMax. Our explanation for necrosis injury was adjuvants in the glyphosate formulation, or oils added to the spray tank, increased necrosis damage as compared with Ultra Blazer alone or Ultra Blazer with non-ionic surfactant (NIS).

Stimtide 7-0-1 is derived from plant-based amino acids and peptides that may aid in reducing the effects of plant stress from certain pesticides. Stimtide improves plant growth and supports enhanced photosynthesis. Some have asked if Stimtide might safen affects from Ultra Blazer or Ultra Blazer mixtures with Roundup PowerMax without lessening waterhemp control. The objectives of these greenhouse experiments were: a) to evaluate necrosis, growth reduction, and fresh weight from Ultra Blazer alone and in mixtures with Roundup PowerMax with and without Stimtide; and b) to determine if Stimtide mixed with Ultra Blazer and NIS changed waterhemp control compared with Ultra Blazer alone. Our hypothesis is Stimtide mixed with Ultra Blazer and NIS will improve sugarbeet safety without affecting waterhemp control as compared with Ultra Blazer and NIS alone.

Materials and Methods

Greenhouse experiments were conducted twice on sugarbeet and once on waterhemp in 2022. A single sugarbeet variety, Betaseed '8961RR' (KWS Seeds LLC, Bloomington, MN) was used to conduct the sugarbeet tolerance experiments. The waterhemp seed source was seed collected from our Moorhead, MN fields. Experiments were a randomized complete block design with replication. Sugarbeet and waterhemp were grown at 75F to 81F under natural light supplemented with a 16 h photoperiod of artificial light.

A total of four equally spaced sugarbeet seeds were planted to a depth of 1-inch in 4 × 4-inch pots containing a 1:1 mixture of Wheatville loam soil (3% OM and pH = 8.1) and PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA). Four waterhemp seedlings were transplanted into 4 × 4-inch pots filled with PROMIX general purpose greenhouse media. Pots were placed in the greenhouse and watered until the 4-leaf sugarbeet growth stage and 4- to 6-inch waterhemp. Herbicide treatments evaluating sugarbeet tolerance (Table 1) and waterhemp control (Table 2) were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8001 XR nozzle calibrated to deliver 10.5 gpa spray solution at 40 psi and 3 mph. Visible necrosis and sugarbeet stature reduction (0% to 100%, 100% indicating complete necrosis and growth reduction) was estimated 7 and 14 days after treatment (DAT). Sugarbeet shoot fresh weight (g per pot) was collected at the conclusion of the experiment. Waterhemp visible control (0% to 100%, 100% indicating complete control was estimated 3, 5, and 10 DAT. Waterhemp shoot fresh weight (g per pot) was collected at the conclusion of the experiment.

Table 1. Herbicide treatment, rate, and sugarbeet growth stage, NDSU greenhouse complex, 2022.

Herbicide Treatment	Herbicide rate	Sugarbeet stage
	-------fl oz/A------	---lvs---
Untreated Control	-	-
Ultra Blazer	16	2 to 4 lvs
Ultra Blazer + NIS	16 + 0.125%	2 to 4 lvs
Ultra Blazer + NIS + AMS	16 + 0.125% v/v + 2.5% v/v	2 to 4 lvs
Ultra Blazer + NIS + AMS + Stimtide	16 + 0.125% + 2.5% v/v + 16	2 to 4 lvs
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.125% v/v	2 to 4 lvs
Ultra Blazer + PowerMax + AMS + NIS + Stimtide	16 + 28 + 2.5% v/v +0.125% v/v + 16	2 to 4 lvs

Data from the greenhouse experiments were analyzed using the MIXED procedure (method=type3) in SAS v. 9.4 (SAS Institute, Cary, NC). Each experiment run was considered a fixed effect. Herbicide treatment was considered a fixed effect while replicate was considered a random effect. If F-test was significant at $P \leq 0.1$, mean separation was performed using least squares means paired differences. The standard error and corresponding error degrees of freedom was used to calculate LSD at a significance level of P=0.1.

Table 2. Herbicide treatment, rate, and waterhemp height, NDSU greenhouse complex, 2022.

Herbicide Treatment	Herbicide rate	Waterhemp height
	---fl oz/A---	--inch--
Untreated Control		
Ultra Blazer + NIS	16 + 0.125%	4-6
Ultra Blazer + Stimtide	16 + 16	4-6
Ultra Blazer + NIS + Stimtide	16 + 0.125% v/v + 16	4-6

Results and Discussion

Sugarbeet injury was assessed visually by quantifying necrotic spots on sugarbeet leaves and sugarbeet growth reduction as compared with the untreated control. Necrosis, growth reduction, and fresh weight were combined and analyzed across runs since Mean Square Error (MSE) for dependent variables were similar. Sugarbeet injury was negligible from Ultra Blazer alone or Ultra Blazer mixed with NIS. Visual necrosis ranged from 2% to 21% in treated pots, 7 DAT, and was greatest when Ultra Blazer or Ultra Blazer and Roundup PowerMax were mixed with NIS and AMS (Table 3). Stimtide reduced necrosis injury from Ultra Blazer but did not reduce necrosis injury from Ultra Blazer and Roundup PowerMax. New sugarbeet leaves did not show necrotic spots.

Table 3. Visual necrosis and growth and fresh weight reduction in response to herbicide treatment, across greenhouse runs, 2022.[a]

Herbicide Treatment	Herbicide rate	Necrosis 7 DAT	Growth Reduction 7 DAT	Growth Reduction 14 DAT	Sugarbeet fresh weight	
	----fl oz /A----	-----------------%-----------------			--g/pot--	-% UTC[b]-
Untreated Control		0 a	8 b	8 a	29.4 a	-
Ultra Blazer	16	3 a	4 a	5 a	28.8 ab	90 ab
Ultra Blazer + NIS	16 + 0.125%	2 a	6 b	4 a	29.7 a	93 a
Ultra Blazer + NIS + AMS	16 + 0.125% + 2.5% v/v	21 c	13 bc	21 bc	26.0 bc	86 bc
Ultra Blazer + NIS + AMS + Stimtide	16 + 0.125% + 2.5% v/v + 16	14 b	8 b	16 b	30.8 a	94 a
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.125% v/v	15 bc	15 c	26 c	25.6 c	85 cd
Ultra Blazer + PowerMax + AMS + NIS + Stimtide	16 + 28 + 2.5% + 0.125% v/v + 16	14 b	19 c	23 c	24.7 c	80 d
LSD (0.10)		8	7	7	4.0	9
P-Value		0.0002	0.0152	0.0001	0.0197	0.0026

[a]Means within a rating that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]UTC=untreated control

Herbicides can slow growth and development until the plant successfully metabolizes them. Growth reduction is often difficult to measure in the field since fields are treated the same. However, minor effects from herbicides are easily observed in the greenhouse. Stimtide mixed with herbicides may accelerate sugarbeet recovery, thus decreasing visual growth reduction compared with herbicides alone. We observed increased sugarbeet stature from Stimtide mixtures with Ultra Blazer as compared with Ultra Blazer alone 7 and 14 DAT; however, differences were not statistically significant. Sugarbeet growth reduction tended to increase when Ultra Blazer was mixed with Roundup PowerMax; however, Stimtide was not able to accelerate sugarbeet recovery as compared with Stimtide and Ultra Blazer alone. Percent sugarbeet fresh weight reduction was less when Stimtide was mixed with Ultra Blazer as compared with Ultra Blazer alone.

Waterhemp control was decreased when Stimtide was mixed with Ultra Blazer and NIS compared with Ultra Blazer and NIS alone (Table 4). We also observed evidence of waterhemp regrowth from one or more growing points from Ultra Blazer plus Stimtide or Ultra Blazer plus Stimtide and NIS. Waterhemp fresh weight tended to be greater and waterhemp control expressed as a percent of fresh weight tend to be less when Stimtide was mixed with Ultra Blazer and NIS.

Table 4. Visual waterhemp control and fresh weight reduction in response to herbicide treatment, greenhouse, 2022.[a]

		Waterhemp control			Waterhemp fresh weight	
Herbicide Treatment	Herbicide rate	3 DAT	5 DAT	10 DAT		
	----fl oz /A----	---------------%---------------			--g/pot--	-% UTC[b]-
Untreated Control		0 d	0 d	0 d	19.5 a	-
Ultra Blazer + NIS	16 + 0.125%	83 a	88 a	93 a	1.7 c	92 a
Ultra Blazer + Stimtide	16 + 16	35 c	45 c	63 c	5.6 b	72 b
Ultra Blazer + NIS + Stimtide	16 + 0.125% v/v + 16	65 b	68 b	80 b	3.0 bc	85 a
LSD (0.10)		14	11	5	4.0	12
P-Value		0.0027	0.0011	0.0001	0.0023	0.0804

[a]Means within a rating that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]UTC=untreated control

Conclusions
Stimtide is marketed to reduce plant stressors affecting plant growth and development including effects caused by herbicides. We observed evidence that Stimtide lessened sugarbeet growth reduction injury caused by Ultra Blazer and improved sugarbeet stature translated to greater sugarbeet fresh weight. However, Stimtide mixed with Ultra Blazer and Roundup PowerMax was not able to overcome sugarbeet growth reduction caused by Ultra Blazer and Roundup PowerMax.

Our results indicate waterhemp control was reduced when Stimtide was mixed with Ultra Blazer, perhaps since waterhemp utilized the same biochemical mechanisms that reduced necrosis injury and stature reduction from Ultra Blazer.

ULTRA BLAZER SECTION 18 EMERGENCY EXEMPTION AND SUPPORTING EXPERIMENTS

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Summary

1. 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 2021.
2. Ninety-two percent of respondents indicated they would willingly support application for a 2022 emergency exemption in sugarbeet.
3. Control from Ultra Blazer decreases as waterhemp size increases from 1-inch to greater than 6-inches.
4. Spray volume (gpa), ground speed (mph), and waterhemp size influenced control and regrowth. Further research and training is needed to optimize waterhemp control.

Introduction

The Environmental Protection Agency (EPA) approved a 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 waterhemp in sugarbeet in 2021. Less than normal rainfall in April and May reduced the efficacy of preemergence (PRE), early postemergence (EPOST), and postemergence (POST) applied soil-residual herbicides. With the discontinuance of Betamix, there are currently no registered POST herbicides for effective waterhemp control that survives 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 of sugarbeet growers who applied Ultra Blazer. The report contains three 2021 program objectives: a) summarize results and user experiences from the 2021 Section 18 emergency exemption for use of Ultra Blazer in sugarbeet; b) summarize an experiment developed to provide producers and agriculturalists with scientific insight as to what Ultra Blazer delivers in sugarbeet production; c) determine reduction in control from Ultra Blazer as waterhemp height increases from 2- to 6-inches.

Materials and Methods

Section 18 Emergency Exemption

Ultra Blazer was applied at 16 fl oz/A alone or with glyphosate and non-ionic surfactant (NIS) plus ammonium sulfate (AMS). One Ultra Blazer application was made per season using ground application equipment and targeted 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 June 2 through July 31, 2021.

Application of Ultra Blazer was targeted to air temperatures less than 85°F 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 85°F, 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 about producer experiences with Ultra Blazer (Appendix).

Sugarbeet Tolerance

Demonstrations plots were established near Casselton, ND and near Crookston, Hendrum, Foxhome and Benson, MN to train producers and agriculturalists on the plant response from Ultra Blazer alone, with glyphosate, and/or with adjuvants (Table 1).

Table 1. Herbicide treatment, rate, and application timing to Ultra Blazer demonstration plots in sugarbeet fields, 2021.

Num	Treatment	Rate (fl oz/A)	Sugarbeet Stage (lvs)
1	Ultra Blazer	16	>6
2	Ultra Blazer + Prefer 90 NIS	16 + 0.125% v/v	>6
3	Ultra Blazer + Prefer 90 NIS	16 + 0.25% v/v	>6
4	Ultra Blazer + Roundup PowerMax + Amsol Liquid AMS	16 + 28 + 2.5 % v/v	>6
5	Ultra Blazer + Roundup PowerMax + Prefer 90 NIS + Amsol Liquid AMS	16 + 28 + 0.25% v/v + 2.5 % v/v	>6

Visible sugarbeet necrosis, malformation, and growth reduction were observed as injury symptoms and evaluated using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. All evaluations were a visual estimate of injury 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 with the ANOVA procedure of ARM, version 2021.2 software package.

Waterhemp Control as Influenced by Height

PRE, EPOST, and POST treatments (Table 2) created waterhemp size and density differences in plots. Late postemergence (LPOST) treatments were applied to evaluate control of waterhemp escapes. Treatments were applied to the center four rows of six row plots 40 feet in length using a bicycle sprayer. Herbicides were applied in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi. Visible sugarbeet necrosis, malformation, and growth reduction were observed as injury symptoms and evaluated using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. All evaluations were a visual estimate of injury 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 with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing in waterhemp control trials, 2021.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax + ethofumesate[1] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	96 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 6 lf / 8-10 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate[1] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 6 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax[3]	16 + 32 + 12 / 16 + 22	4 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	16 + 32 + 12 / 16 + 22	6 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	16 + 28 + 6 / 16 + 28 + 6 / 16 + 22	4 lf / 6 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 22	PRE / 4 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 22	PRE / 6 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 32 + 12 / 16 + 22	PRE / 4 lf / 6 lf / 8-10 lf

[1]Roundup PowerMax + ethofumesate applied with Destiny HC @ 1.5 pt/A + Amsol AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Roundup PowerMax + Ultra Blazer applied with Prefer 90 NIS @ 0.25% v/v and NPak AMS at 2.5% v/v.

Results

According to a survey of sugarbeet growers and agriculturalists, Ultra Blazer at 16 fl oz/A was applied to 32,005 sugarbeet acres in 2021 (totaling 4,001 gallons of Ultra Blazer). Ninety percent or 28,711 acres were applied in Minnesota and 10% or 3,294 acres were applied in North Dakota.

The air temperature at application and variability in sugarbeet growth stage complicated Ultra Blazer application, especially applications made in early June, 2021. The maximum daily air temperature in much of the sugarbeet growing area (represented by Hillsboro, ND and Blomkest, MN) was 80 to 102°F from June 2 through at least June 15, 2021 (Figure 1). In the five years (2016 to 2020) leading up to the Section 18 application for Ultra Blazer, air temperature at application had not been greater than 85°F in any of our research trials.

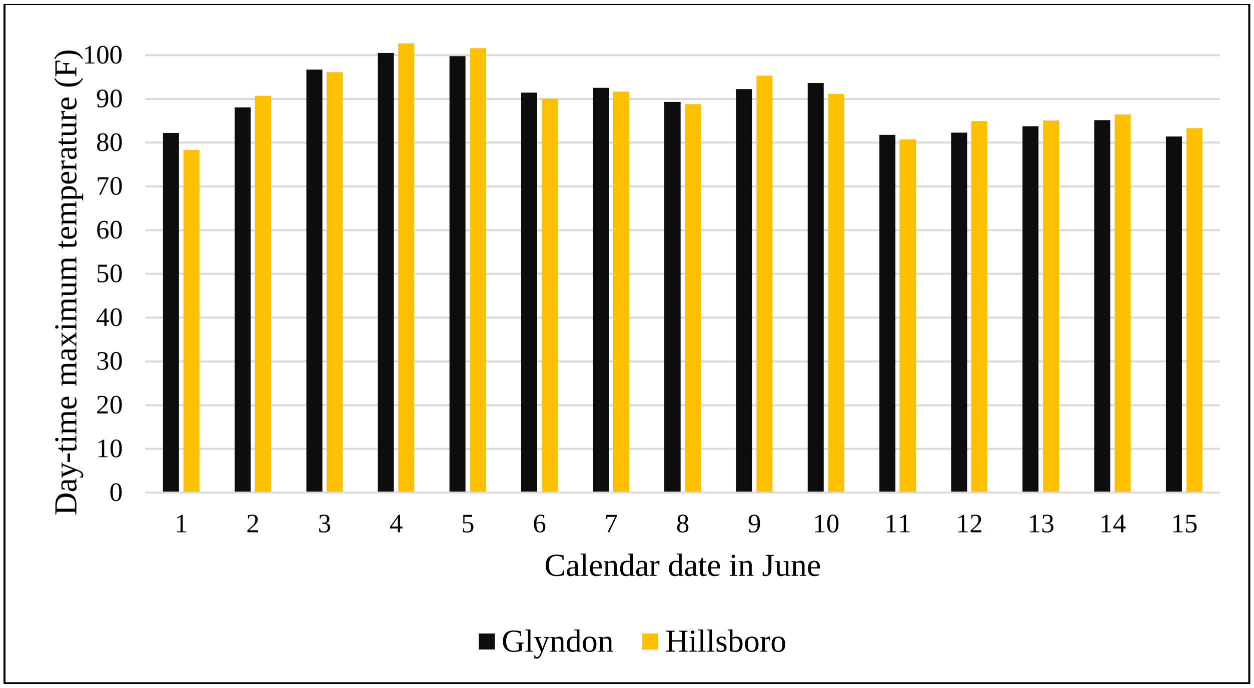

Figure 1. Day time maximum air temperature, June 1 to June 15, Hillsboro, ND and Blomkest, MN, 2021.

The variability of sugarbeet growth stage at application further complicated Ultra Blazer application. Our recommendation was for application to sugarbeet greater than the 6-lf stage. However, dry planting conditions in April and May caused variable emergence and sugarbeet stands ranged from cotyledon to 8-lf at application.

Sugarbeet producers and agriculturalists were asked in a survey to evaluate sugarbeet injury and waterhemp control from Ultra Blazer. When compiling sugarbeet injury responses, no injury = 1, slight = 2, moderate = 3, and severe injury = 4. When compiling waterhemp control responses, excellent =1, good = 2, fair = 3, and poor control = 4. When averaged across all responses, sugarbeet injury was reported as slight to moderate (2.6) and waterhemp control as good to fair (Figure 2). Only one respondent categorized sugarbeet injury as severe. Respondents from the northern Red River Valley (RRV) graded injury greater (2.8) than respondents from the southern RRV (2.4) or respondents from west central Minnesota (2.6) suggesting their lack of familiarity with or tolerance for sugarbeet injury. Waterhemp control was rated good to fair with negligible differences in responses across the growing regions. Although no unintended effects such as increased susceptibility to disease or reduced % sucrose content were reported by producers or agriculturalists, there were inconsistent results in regard to sugarbeet tolerance and waterhemp control. This indicates a need for application method refinements if Ultra Blazer is used on sugarbeet in the future. Agriculturalists and producers were asked if they found the Section 18 Emergency Exemption useful and if they supported applying for a 2022 Emergency Exemption. Ninety-five percent of the respondents found the Section 18 Emergency Exemption beneficial for sugarbeet growers and 92% supported reapplication for the Emergency Exemption in 2022.

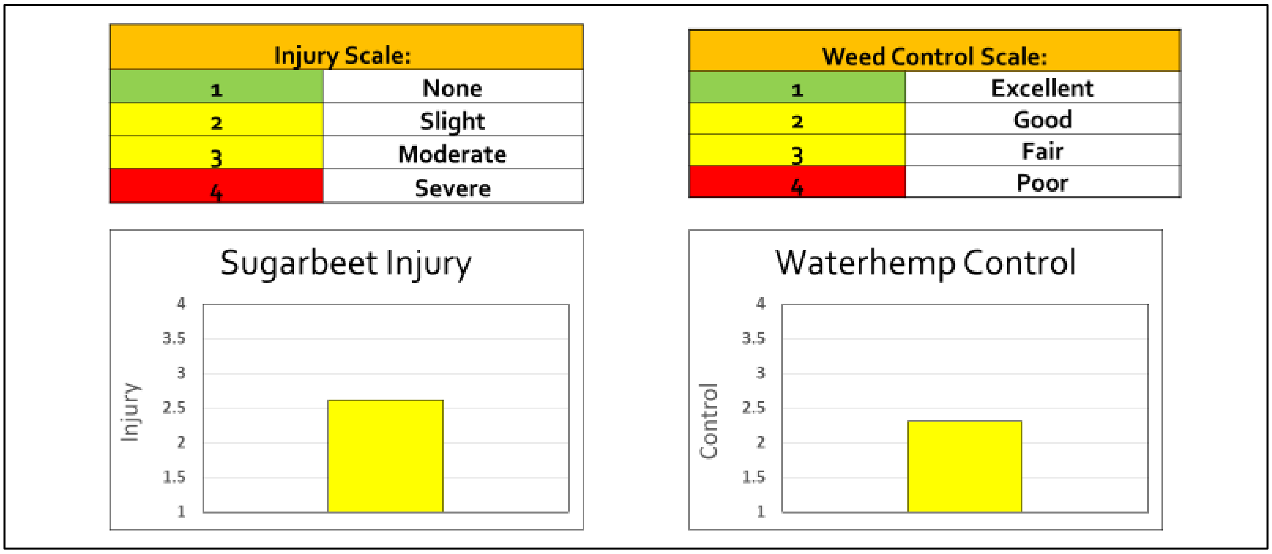

Figure 2. Results of producer and agriculturalist survey of sugarbeet injury and waterhemp control from Ultra Blazer Section 18 Emergency Exemption, Minnesota and North Dakota, 2021.

Ultra Blazer is a contact herbicide PPO inhibitor that is applied POST and is light activated. When activated, this product forms highly reactive compounds in the plants that rupture cell membranes causing fluids to leak. Injury symptoms can occur as soon as 1 to 2 hours after application. Environmental conditions will affect Ultra Blazer injury to sugarbeet. Symptoms are most apparent with bright, sunny conditions and increased humidity at application.

Efficacy is best when Ultra Blazer is used at high water volumes (15 to 25 gpa water volume) with flat fan nozzles producing a fine droplet spectrum to ‘paint the plant’ ensuring good coverage. Oil-based adjuvants with Ultra Blazer increase waterhemp control and sugarbeet injury as compared with non-ionic surfactants. Likewise, herbicide mixtures, including glyphosate, will potentially increase sugarbeet injury.

Sugarbeet Tolerance
Sugarbeet visual percent injury was evaluated 3 to 16 days after treatment (DAT) across locations. Sugarbeet injury ranged from 8% to 40% depending on herbicide treatment and location (Table 3). Sugarbeet injury tended to be less with Ultra Blazer alone and increased with addition of adjuvant and/or adjuvant rate. Sugarbeet injury increased when Roundup PowerMax was mixed with Ultra Blazer as compared with Ultra Blazer alone or with adjuvants. Sugarbeet injury was greatest at Benson, MN. The air temperature at Benson at 11:00AM was 95°F. Air temperature was 88°F, 79°F, 88°F, and 86°F at application at Casselton, Crookston, Foxhome, and Hendrum, respectively. Root yield, % sucrose, and recoverable sucrose was collected at Hendrum, MN. Yield parameters were collected by hand from a 37 square foot area. This is approximately 1/3 of our normal mechanically harvested area. Data was variable but suggested reduced yield when adjuvant or Roundup PowerMax was mixed with Ultra Blazer compared with applying Ultra Blazer alone. Percent sucrose was the same across treatments.

Table 3. Visual percent sugarbeet injury in response to herbicide treatment, 3 to 16 DAT at multiple locations, 2021[a].

Herbicide Treatment	Adj. Rate[b]	Casselton	Crookston	Foxhome	Hendrum	Benson
	--pt/100 gal--	----------------------------------	-----------	%	-----------	-----------
Ultra Blazer[c]	-	9 d	9 c	10 c	8 d	-
Ultra Blazer + Prefer 90 NIS	1	14 c	10 bc	11 bc	10 cd	-
Ultra Blazer + Prefer 90 NIS	2	15 bc	15 ab	18 b	15 c	-
Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	-	-	-	-	35
RUPM[d] + Ultra Blazer + Amsol liquid AMS	20	19 b	20 a	25 a	21 b	-
RUPM[d] + Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	28 a	-	26 a	30 a	40
LSD (0.10)		**4**	**5**	**6**	**6**	**NS**

[a]Means within a location not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Adj. Rate = Adjuvant Rate.
[c]Ultra Blazer applied at 16 fl oz/A in all treatments.
[d] RUPM = Roundup PowerMax applied at 28 fl oz/A in respective treatments.

Table 4. Visual percent sugarbeet injury and sugarbeet yield parameters in response to herbicide treatment, Hendrum, MN, 2021[a].

Herbicide Treatment	Adj. Rate[b]	Sgbt inj[c]	Sgbt inj	Yield	Sucrose	Rec Suc[d]
	--pt/100 gal--	---------%	---------	-Ton/A-	--%--	--lb/A--
Ultra Blazer[e]	-	8 d	0 b	27.1 a	17.8	9,002 a
Ultra Blazer + Prefer 90 NIS	1	10 cd	0 b	24.7 b	17.6	8,091 ab
Ultra Blazer + Prefer 90 NIS	2	15 c	3 b	24.4 b	17.9	8,163 ab
RUPM[f] + Ultra Blazer + Amsol liquid AMS	20	21 b	10 a	24.1 b	17.6	7,864 b
RUPM[f] + Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	30 a	10 a	25.2 ab	18.1	8,514 ab
LSD (0.10)		**6**	**4**	**2.4**	**NS**	**944**

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Adj. Rate = Adjuvant Rate.
[c]Sgbt inj. = Sugarbeet Injury.
[d]Rec. Suc. = Recoverable Sucrose.
[e]Ultra Blazer applied at 16 fl oz/A in all treatments.
[f]RUPM = Roundup PowerMax applied at 28 fl oz/A in respective treatments.

Waterhemp Control as Influenced by Height

Waterhemp control decreased as waterhemp size increased at Blomkest and Moorhead (Figure 3). The negative slope of the line was greater at Moorhead than Blomkest indicating waterhemp control decreased more rapidly at Moorhead than at Blomkest in response to waterhemp height. Air temperature was 75°F at application at Moorhead and Blomkest. Sugarbeet size and growth stage was greater at Moorhead, which may have reduced herbicide coverage on waterhemp as compared with the Blomkest location.

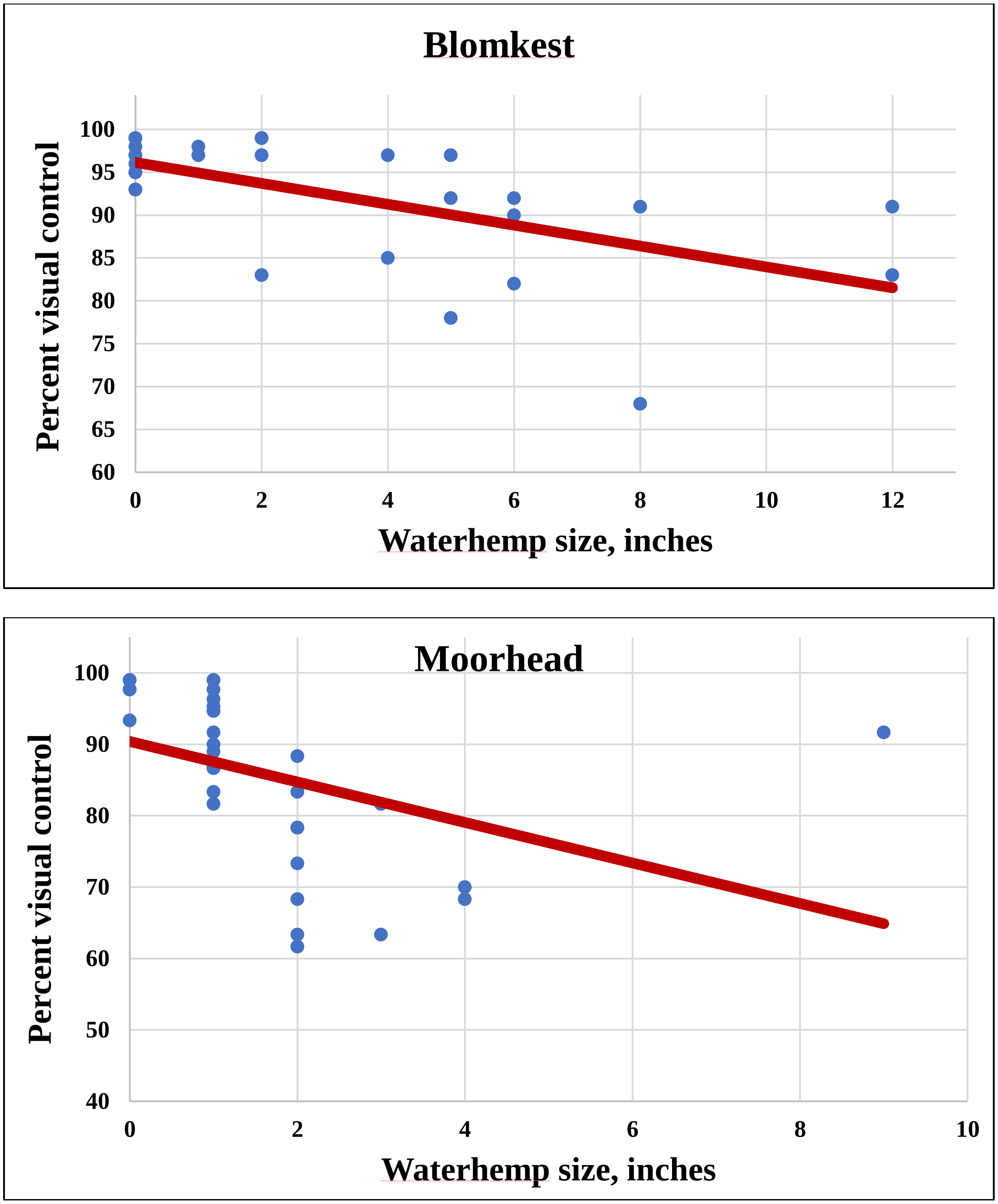

Figure 3. Visual percent waterhemp control in response to waterhemp size, Blomkest and Moorhead, MN, 2021.

Conclusion

Using Ultra Blazer will be a compromise between sugarbeet injury and weed control. Methods to improve control such as adjuvant selection and rate or herbicides tank-mixed with Ultra Blazer, as well as environmental conditions at application, must be considered as different combinations will increase sugarbeet injury. Application must be timed to sugarbeet greater than 6-lf sugarbeet with the prospect that weed escapes range from 2- to 4-inches. We learned in 2021 that producers are willing to sacrifice sugarbeet safety to control weed escapes. Further research is needed to improve spray quality including selection of nozzles and spray volume to optimize weed control.

Appendix.

2021 Ultra Blazer Section 18 Emergency Exemption

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 from Ultra Blazer?

   None Slight Moderate Severe

4. Record weed control from Ultra Blazer in sugarbeet?

   Excellent Good Fair Poor

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 2022?

   YES NO.

Write comments to provide additional details regarding your experiences.

____

____

____

VOLUNTEER ROUNDUP READY CANOLA CONTROL WITH ULTRA BLAZER

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Summary

1. Ultra Blazer applied at 16 fl oz/A with non-ionic surfactant at 0.125% v/v controlled 2- to 3-inch and 4- to 6-inch canola.
2. Although sugarbeet safety was not an objective of this experiment, we remind producers that sugarbeet must be greater than 6-lf stage for application of Ultra Blazer.

Introduction

Volunteer Roundup Ready® Canola is one of the most difficult weeds to control in sugarbeet. Our previous research established UpBeet (triflusulfuron-methyl, group 2) as the most effective herbicide for volunteer canola control. Volunteer canola germinates and emerges across time in sugarbeet so repeat UpBeet applications are the only effective approach for control. Sugarbeet Extension recommends two or three repeat UpBeet applications at 0.5 to 0.75 lb/A once volunteer canola has reached the 2-lf stage.

Adam Bernhardson from North Star Ag Services wrote and mentioned that Flexstar, (fomesafen, group 14) at low rates has proven to be an excellent way to control volunteer canola in soybean. Adam inquired if Ultra Blazer might be equally as effective in sugarbeet since the herbicides share the same mode of action. The objective of this experiment was to determine control of 2- to 3-inch and 4- to 6-inch volunteer canola from Ultra Blazer.

Materials and Methods

A single greenhouse experiment was conducted in 2022. Pots were filled with PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA) and four equally spaced canola seeds were planted to a depth of 1-inch in 4 × 4-inch pots. Canola were grown to 2- to 3-inch and 4- to 6-inch at 75F to 81F under natural light supplemented with a 16 h photoperiod of artificial light. Herbicide treatments (Table 1) were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8001 XR nozzle calibrated to deliver 10.5 gpa spray solution at 40 psi and 3 mph. Visible canola control (0% to 100%, 100% indicating complete control) was evaluated 3, 7, and 14 days after treatment (DAT). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Herbicide treatment, rate, and volunteer RR canola growth stage, NDSU greenhouse complex, 2022.

Herbicide Treatment	Herbicide rate	Sugarbeet stage
	-------fl oz /A-------	--leaves--
Untreated Control	-	-
Ultra Blazer	16	2-3
Ultra Blazer + NIS[a]	16 + 0.25%	2-3
Ultra Blazer + PowerMax + AMS[b] + NIS	16 + 28 + 2.5% v/v +0.25% v/v	2-3
Ultra Blazer	16	4-6
Ultra Blazer + NIS	16 + 0.25%	4-6
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.25% v/v	4-6

[a]NIS=non-ionic surfactant
[b]AMS=liquid ammonium sulfate

Results and Discussion

Ultra Blazer alone, Ultra Blazer with non-ionic surfactant (NIS) or Ultra Blazer with Roundup PowerMax and NIS and ammonium sulfate (AMS) controlled 2- to 3-inch canola, 8 DAT. Control from Ultra Blazer with NIS or Ultra Blazer with Roundup PowerMax with NIS and AMS provided similar control, 8 DAT, on 4- to 6-inch canola. However, Ultra Blazer alone provided less 4- to 6-inch canola control than Ultra Blazer with NIS, 8 DAT. However, sugarbeet must be greater than the 6-lf stage to achieve acceptable sugarbeet safety.

Table 2. Visual growth reduction in response to herbicide treatment and growth stage, greenhouse, 2022.[a]

		Growth	Canola growth reduction				
Herbicide Treatment	Herbicide rate	Stage	3 DAT[b]	3 DAT	8 DAT	8 DAT	13 DAT
	------fl oz /A------	--lvs--	----------------------------%----------------------------				
Untreated Control			0 d	0 c	0 b	0 c	0 b
Ultra Blazer	16	2-3	50 c	-	97 a	-	98 a
Ultra Blazer + NIS[c]	16 + 0.25%	2-3	78 a	-	98 a	-	99 a
Ultra Blazer + PowerMax + AMS[d] + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	2-3	60 b	-	99 a	-	99a
Ultra Blazer	16	4-6	-	65 b	-	81 b	-
Ultra Blazer + NIS	16 + 0.25%	4-6	-	73 ab	-	94 a	-
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	4-6	-	76 a	-	96 a	-
LSD (0.10)			9	10	2	6	1
P-Value			0.0001	0.0001	0.0001	0.0001	0.0001

[a] Means within a rating that do not share any letter are significantly different by the LSD at the 10% level of significance.

[b]DAT=Days after treatment

[c]NIS=Non-ionic surfactant

[d]AMS=liquid ammonium sulfate

Conclusions

Ultra Blazer controls volunteer RR canola. NIS is usually recommended with Ultra Blazer. NIS with Ultra Blazer improved control of 4- to 6-inch canola as compared with Ultra Blazer alone. We did not attempt to control canola greater than 6-inches. It would surmise that Ultra Blazer would provide control of canola greater than 6-inches, provided there was good coverage.