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.

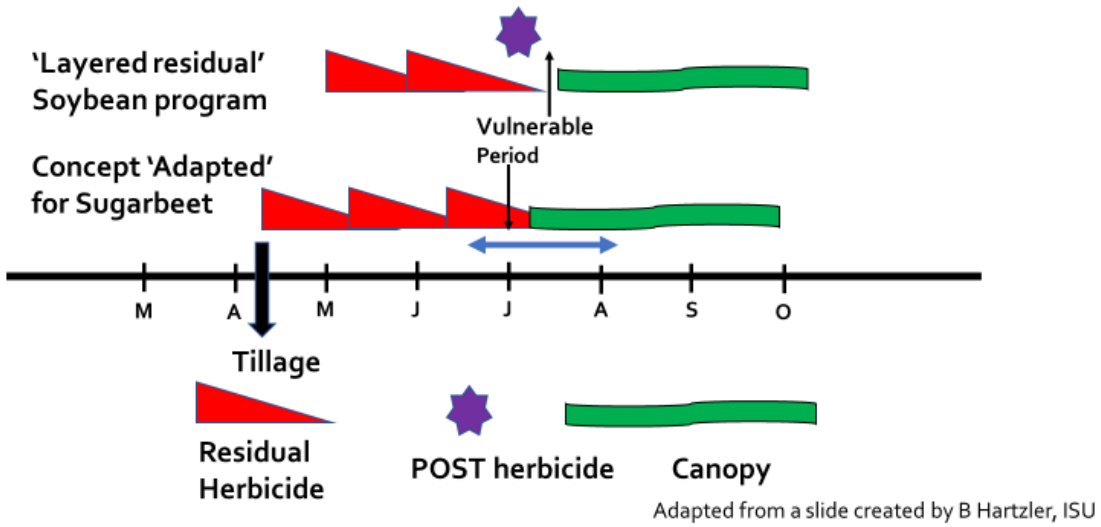

Figure 1. A demonstration of layered soil residual herbicides creating a herbicide barrier in soil from planting through canopy closure.

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.

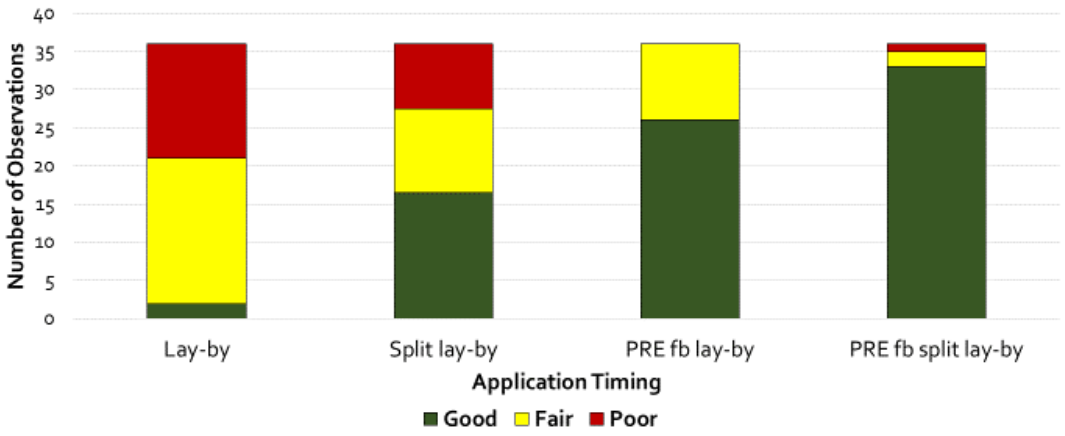

Figure 2. Number of observations with good (greater than 85%), fair (65% to 84%), and poor (less than 64%) waterhemp control in response to herbicide treatment and application timing summed across evaluations and locations, 2014 to 2016.

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.

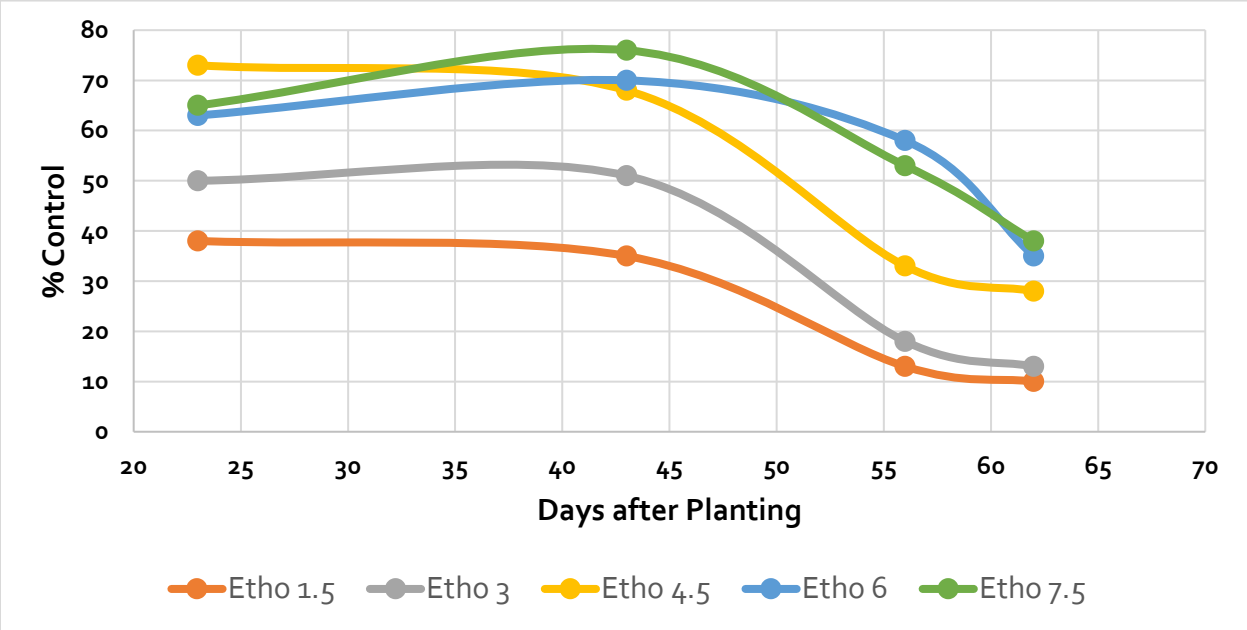

Figure 3. Visible waterhemp control 23 to 63 days after planting (DAP) in response to ethofumesate rate, Moorhead, MN, 2020.

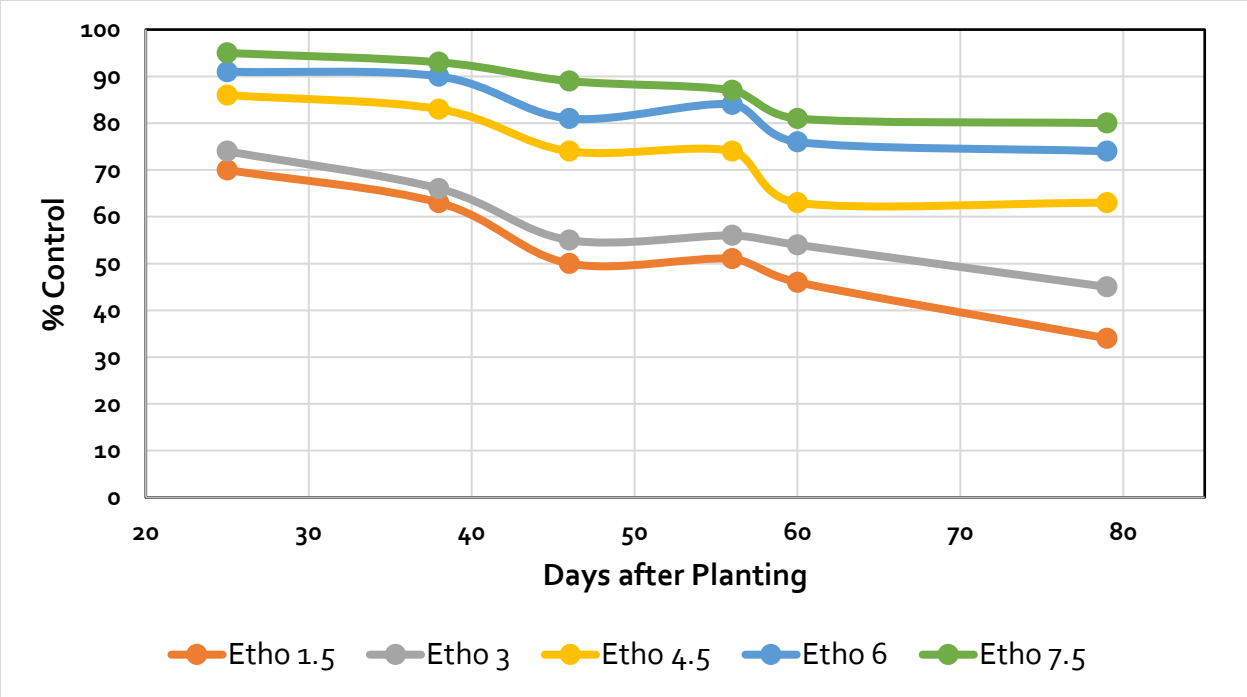

Figure 4. Visible waterhemp control 25 to 80 days after planting (DAP) in response to ethofumesate rate, Blomkest, MN, 2020.

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.

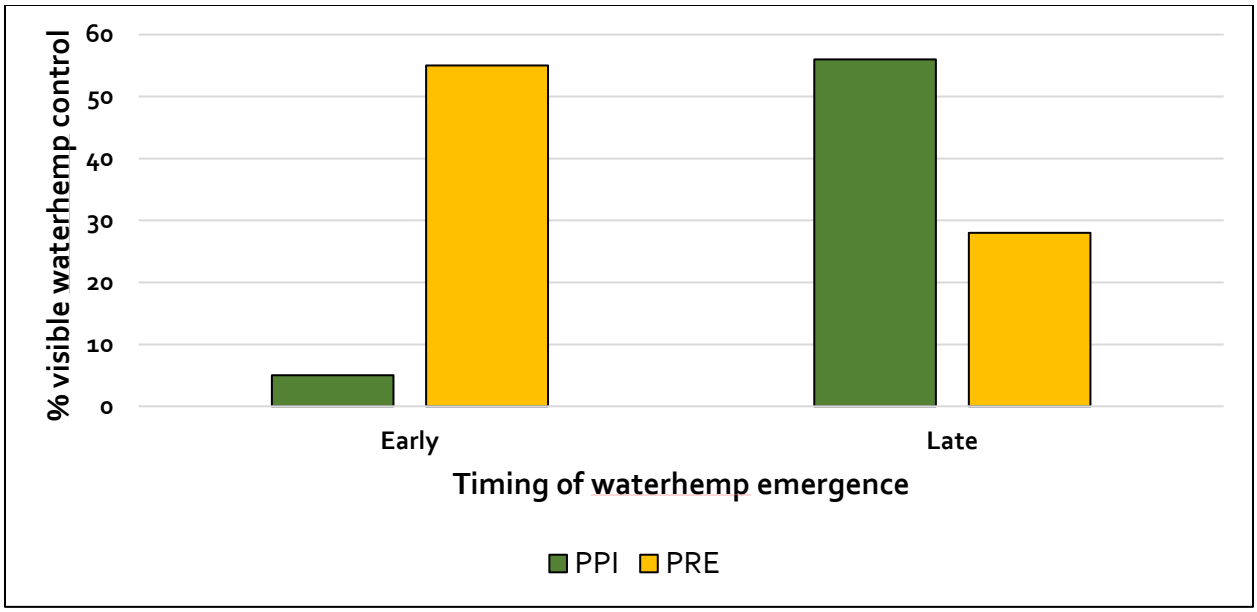

Figure 5. Early and late germinating waterhemp control in response to ethofumesate PPI and PRE, Fargo, 2021.

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.

References

1. McAuliffe, D., and Appleby, A.P. 1984. Activity loss of ethofumesate in dry soil by chemical degradation and Adsorption. Weed Sci. 32:468-471