WATERHEMP CONTROL FROM SOIL RESIDUAL PREEMERGENCE AND POSTEMERGENCE HERBICIDES IN 2022

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Summary

1. Layering soil residual herbicides, beginning with preemergence (PRE) herbicide at planting, is our most effective strategy for controlling waterhemp in sugarbeet.
2. Differences in waterhemp control may occur, especially when rainfall is absent or not timely.
3. We do not completely understand the environmental conditions where ethofumesate fails to provide waterhemp control or why lack of control occurs.
4. Roundup PowerMax3 mixed with Ultra Blazer improved waterhemp control when soil residual herbicides failed due to lack of rainfall for activation.
5. Ultra Blazer mixed with Roundup PowerMax3 causes significant sugarbeet growth reduction injury which may cause loss of root yield compared with our soil residual waterhemp control standards, despite providing very good waterhemp control.

Introduction

Waterhemp control is our most important weed management challenge in sugarbeet according to the annual growers survey. Waterhemp is both common and troublesome in fields planted to sugarbeet for multiple reasons including full-season germination and emergence, prolific seed production, genetic diversity, and herbicide resistance. To date, waterhemp has shown 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).

The foundation of the waterhemp control program in sugarbeet is 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.

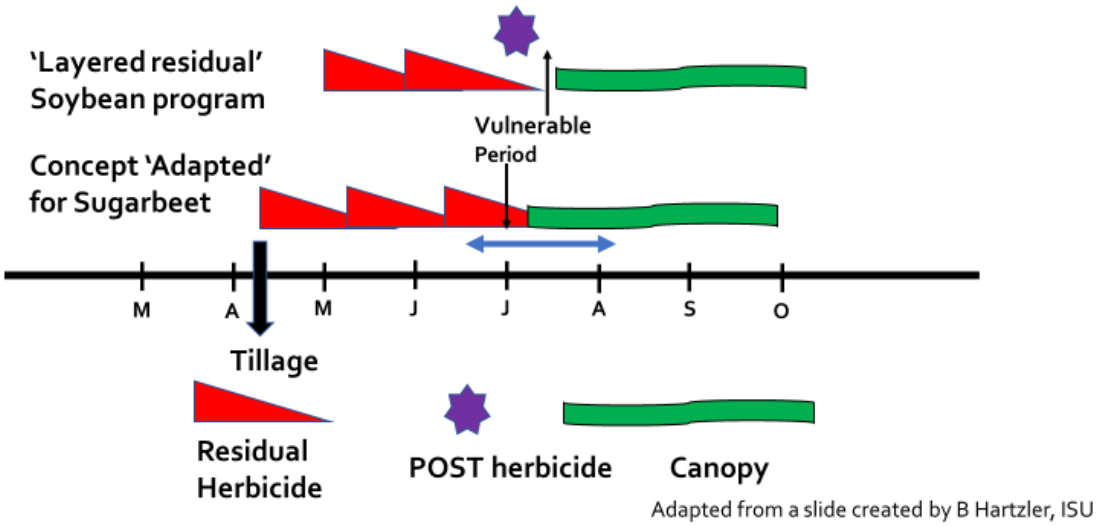

Figure 1. A demonstration of layered soil residual herbicides creating a herbicide barrier in soil from planting through canopy closure.

Calendar year 2022 created some unique challenges for sugarbeet growers. First, the spring was wet, resulting in average planting dates approximately 21 days later than the 20-year averages. Second, June and July rainfall were below normal in areas, compromising activation of soil residual herbicides (Figure 2).

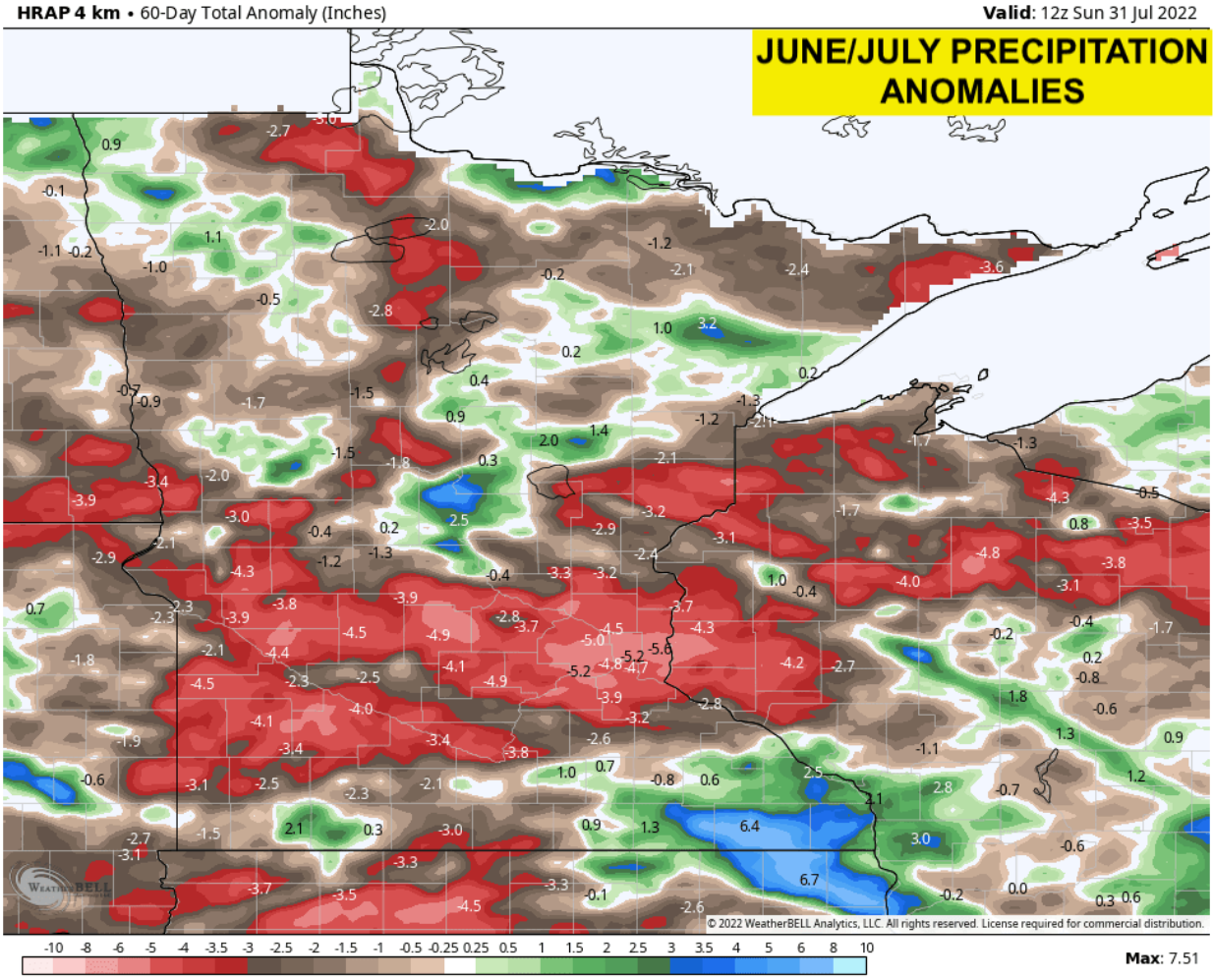

Figure 2. June and July, 2022 precipitation anomalies, Bring Me the News, Meteorologist Sven Sundgaard https://bringmethenews.com/minnesota-weather/july-2022-in-minnesota-was-hotter-windier-and-drier-than-normal.

The objectives of these experiments were 1) to demonstrate a weed control system for waterhemp control in sugarbeet, 2) to reinforce previous waterhemp control messages and practices for audiences with experience in waterhemp control, and 3) to examine differences in waterhemp control across experiments and investigate factors contributing to control.

Materials and Methods

Experiments were conducted near Blomkest, Moorhead, and Sabin, MN in 2022. Treatments are listed in Table 1. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 27 at Blomkest, May 25 at Moorhead, and May 19 at Sabin in 2022. Sugarbeet was seeded in 22-inch rows at approximately 62,000 seeds per acre with 4.6 inch spacing between seeds. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through XR8002 flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length.

Table 1. Herbicide treatment, rate, and application timing, Blomkest, Moorhead, and Sabin MN, 2022.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (fl oz/A)	Sugarbeet stage (lvs)
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[b]	25 + 6 / 25 + 16	2 / 6-8
No	Outlook / Outlook	12 / 12	2 / 6-8
No	Warrant / Warrant	48 / 48	2 / 6-8
No	Outlook / Warrant	12 / 48	2 / 6-8
No	Outlook / Warrant	12 / 64	2 / 6-8
Yes[c]	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	PRE/2 / 6-8
Yes	Outlook / Outlook	12 / 12	PRE/2 / 6-8
Yes	Warrant / Warrant	48 / 48	PRE/2 / 6-8
Yes	Outlook / Warrant	12 / 48	PRE/2 / 6-8
Yes	Outlook / Warrant	12 / 64	PRE/2 / 6-8

[a]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with every POST application that did not contain Ultra Blazer.
[b]Ultra Blazer applied with Roundup PowerMax 3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.
[c]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE at Bloomkest and Sabin or ethofumesate at 6 pt/A PRE at Moorhead.

Visible sugarbeet growth reduction injury was evaluated using a 0 to 100% scale with 0% representing no visible injury and 100% as complete loss of plant / stand) approximately 7 and 14 days (+/- 3 days) following the 6-8 leaf application. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) and was collected 59, 90, and 94 days after planting. 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 2022.5 software package.

At harvest, sugarbeet was defoliated and harvested mechanically from the center two rows of each plot and weighed at Moorhead and Sabin, MN. An approximate 30-pound sample was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, ND).

Results

Experiments at Blomkest and Moorhead, MN were planted later than average due to continuous spring rainfall in 2022. As a result, sugarbeet stands were variable at both locations. At Moorhead, experiments were planted into a cloddy seedbed. It was extremely dry at planting at Blomkest. In addition, excessively strong winds on June 21 partially defoliated sugarbeet. Timely rainfall events were measured at Moorhead in June and July following herbicide applications and in July at Sabin, MN; however, rainfall was much less at the Blomkest location (Table 2).

Table 2. Cumulative rainfall the first 10 days following herbicide application, across locations, 2022.

Herbicide Treatment	Moorhead, MN[a]	Sabin, MN	Blomkest, MN[b]
	----------inch----------		
PRE Application	1.0	0.5	0.9
EPOST Application	1.7	0.4	0.0
POST Application	1.8	2.4	0.5
Total:	**4.5**	**3.3**	**1.4**

[a]Moorhead and Sabin precipitation data collected from nearby weather stations operated by North Dakota Agricultural Weather Network (NDAWN)
[b]Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific.

Sugarbeet injury from soil residual herbicides ranged from 0% to 29% across evaluations and experiments (Table 3). Sugarbeet injury from soil residual herbicides tended to be greatest at Sabin and was less at Bloomkest and Moorhead. Assessment of sugarbeet injury at Bloomkest was complicated by erratic stands due to dry conditions and strong winds, which partially defoliated sugarbeet. At Sabin, sugarbeet injury from soil residual herbicides was observed 7 days after treatment (DAT) and remained visible 14 DAT, especially from PRE / EPOST / POST treatments.

Sugarbeet injury from Ultra Blazer + Roundup PowerMax3 POST ranged from 35% to 53% across locations and was greater than sugarbeet injury from soil residual herbicides POST (Table 3). Applying ethofumesate or ethofumesate + Dual Magnum PRE did not impact sugarbeet injury from Roundup PowerMax3 + ethofumesate followed by (fb) Roundup PowerMax3 + Ultra Blazer. Sugarbeet injury from Ultra Blazer declined numerically between the first and second evaluation.

Table 3. Sugarbeet visible injury in response to PRE and POST treatment, across locations, 2022.[a]

Herbicide Treatment	Herbicide Treatment		Sugarbeet Injury[b]					
			Sabin, MN		Moorhead, MN		Blomkest, MN	
PRE[c]	POST[d]	Rate	7 DAT	17 DAT	10 DAT	15 DAT	9 DAT	18 DAT
		-fl oz/A-	----------%----------					
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	44 d	38 d	50 c	34 b	53 b	46 b
No	Outlook / Outlook	12 / 12	11 a	4 a	0 a	0 a	0 a	6 a
No	Warrant / Warrant	48 / 48	9 a	0 a	0 a	3 a	0 a	11 a
No	Outlook / Warrant	12 / 48	29 c	14 bc	0 a	5 a	0 a	5 a
No	Outlook / Warrant	12 / 64	9 a	3 a	16 b	4 a	0 a	0 a
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	50 d	35 d	50 c	48 b	48 b	41 b
Yes	Outlook / Outlook	12 / 12	13 ab	8 ab	0 a	0 a	0 a	5 a
Yes	Warrant / Warrant	48 / 48	20 abc	20 c	11 b	5 a	0 a	3 a
Yes	Outlook / Warrant	12 / 48	24 bc	15 bc	0 a	5 a	0 a	4 a
Yes	Outlook / Warrant	12 / 64	19 abc	4 a	8 a	0 a	0 a	8 a
LSD (0.10)			**12**	**8**	**9**	**8**	**5**	**11**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Sugarbeet injury evaluations were approximately 7 and 14 days after application C, Ultra Blazer.
[c]Ethofumesate + Dual Magnum PRE at 2 + 0.5 pt/A at Blomkest and Sabin. Ethofumesate PRE at 6 pt/A at Moorhead.
[d]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with every POST application that did not contain Ultra Blazer.
[e]Ultra Blazer applied with Roundup PowerMax 3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Waterhemp (with some redroot pigweed) control ranged from 36% to 96% across treatments and locations (Table 4). The average control across all treatments was 52%, 93% and 95% for Blomkest, Moorhead and Sabin, respectively. At Sabin, repeat Warrant applications or Outlook fb Warrant tended to provide waterhemp control greater than repeat Outlook applications. Addition of ethofumesate mixtures with Dual Magnum PRE did not improve waterhemp control. Waterhemp control was greatest from Roundup PowerMax3 mixtures with soil residual herbicides at Sabin compared with other locations.

Waterhemp control from soil residual herbicides applied POST which contained Warrant, or Outlook followed by Warrant, provided similar waterhemp control at Moorhead and Sabin. PRE herbicides followed by POST herbicides tended to provide waterhemp control similar to POST treatments alone. The exception was at Moorhead where the absence of PRE herbicides resulted in reduced waterhemp control from repeat POST Outlook applications.

Ultra Blazer mixed with Roundup PowerMax3 following ethofumesate PRE provided or tended to provide waterhemp control similar to soil residual herbicides POST. However, control was less when Ultra Blazer and Roundup PowerMax3 were applied without PRE ethofumesate.

Table 4. Waterhemp control in response to PRE and POST treatment, across location, 2022.[a]

Etho or Etho+DM PRE[b]	Soil Residual Treatment POST[c]	Rate	Waterhemp Control Blomkest, MN 59 DAP[d]	Moorhead, MN 90 DAP	Sabin, MN 94 DAP
		--fl oz/A--	----------%----------		
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	63 ab	63 c	84 c
No	Outlook / Outlook	12 / 12	36 e	89 b	97 ab
No	Warrant / Warrant	48 / 48	54 bc	99 a	98 ab
No	Outlook / Warrant	12 / 48	43 de	96 ab	98 ab
No	Outlook / Warrant	12 / 64	54 bc	99 a	99 a
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	71 a	98 a	90 bc
Yes	Outlook / Outlook	12 / 12	43 de	99 a	98 ab
Yes	Warrant / Warrant	48 / 48	49 cd	99 a	99 a
Yes	Outlook / Warrant	12 / 48	56 bc	93 ab	92 ab
Yes	Outlook / Warrant	12 / 64	49 cd	99 a	96 ab
LSD (0.10)			**9**	**9**	**9**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Ethofumesate + Dual Magnum PRE at 2 + 0.5 pt/A at Blomkest and Sabin. Ethofumesate PRE at 6 pt/A PRE at Moorhead.
[c]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with every POST application that did not contain Ultra Blazer.
[d]DAP=Days after plant
[e]Ultra Blazer applied with Roundup PowerMax3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Waterhemp control from PRE herbicides were inconsistent and unacceptable at Blomkest, MN. We credit trial inconsistency to variable weed pressure across the experiment due to dry conditions in June. An on-site rainfall collection device recorded 0.79 inches of rainfall May 30 or three days after PRE application (Table 5). This rainfall event should have been sufficient to activate ethofumesate and Dual Magnum PRE. However, sub-optimal weed control was observed on June 21 (data not included in this report) contributing to the overall lack of control, even from PRE herbicides at Blomkest. We believe the lack of early season waterhemp control from the PRE herbicides contributed to the lack of POST control from glyphosate, ethofumesate and soil residual herbicides.

Table 5. Hourly rainfall measurements, May 30, 2022, near Blomkest, MN.[a]

Hour	Rainfall (inch)
Midnight to 5:00AM	0.00
5:00AM to 7:00AM	0.04
8:00AM to 9:00AM	0.27
9:00AM to 10:00AM	0.17
10:00AM to noon	0.10
1:00PM to 5:00PM	0.01
6:00PM to 7:00PM	0.18
7:00PM to 8:00PM	0.02
8:00PM to midnight	0.00

[a] Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific.

Sabin was also very dry in early June. However, in contrast to Blomkest, we do not believe there was waterhemp seed germination and emergence throughout May and the first half of June at Sabin, MN. We did have sufficient moisture for sugarbeet emergence and observed uniform stands. Soil residual herbicides were activated by late June and July rainfall, resulting in excellent weed control. We are unsure if the PRE herbicide treatment was activated at Sabin; however, the POST herbicide treatments delivered effective control as compared with the control strips imbedded in the experiment.

Ultra Blazer mixed with Roundup PowerMax3 alone or following ethofumesate at 6 pt/A PRE reduced sugarbeet root yield and recoverable sucrose as compared with soil residual herbicides mixed with Roundup PowerMax3 (Table 6). Herbicide treatments did not affect % sucrose.

Ultra Blazer was mixed with Roundup PowerMax3 in 2022. Roundup PowerMax3 was a new glyphosate formulation, containing 5.88 pounds of glyphosate per gallon as compared with 4.6 pounds of glyphosate per gallon in Roundup PowerMax. The experiments did not contain either the Roundup PowerMax3 alone treatment or Roundup PowerMax plus Ultra Blazer treatment.

Table 6. Root yield, % sucrose and recoverable sucrose in response to herbicide treatment, Moorhead MN, 2022.[a]

Etho PRE[b]	Soil Residual Treatment POST[c]	Rate	Root Yield	Sucrose	Recoverable sucrose/A
		--fl oz/A--	---TPA[d]---	---%---	----lb/A----
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	21.2 c	14.9	5,658 c
No	Outlook / Outlook	12 / 12	26.5 ab	15.1	7,147 ab
No	Warrant / Warrant	48 / 48	27.5 a	14.7	6,900 ab
No	Outlook / Warrant	12 / 48	29.1 a	15	7,838 a
No	Outlook / Warrant	12 / 64	28.4 a	15.2	7,237 ab
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	24.0 b	14.9	6,280 bc
Yes	Outlook / Outlook	12 / 12	26.8 a	15.1	7,236 ab
Yes	Warrant / Warrant	48 / 48	28.5 a	15.3	7,895 a
Yes	Outlook / Warrant	12 / 48	27.2 a	14.8	7,124 ab
Yes	Outlook / Warrant	12 / 64	28.1 a	15.1	7,683 a
LSD (0.10)			**2.7**	**NS**	**1,031**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Ethofumesate at 6 pt/A PRE applied at Moorhead.
[c]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with every POST application that did not contain Ultra Blazer.
[d]TPA=Tons per acre.
[e]Ultra Blazer applied with Roundup PowerMax3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Our best research practices are not to harvest weed control experiments. In this situation, however, we felt that quantifying yield from sugarbeet treated with Ultra Blazer in a waterhemp rich environment would enable us to demonstrate that weed control from Ultra Blazer might off-set sugarbeet injury.

Conclusion

Rainfall is critical for achieving satisfactory waterhemp control from soil residual herbicides. Evaluating the impact of moisture on herbicide activity was not the primary objective for the experiment, but the observations around the relationship of moisture and herbicide activity became an important benefit from the experiment, especially considering the lack of waterhemp control experienced by many growers in Southern Minnesota Beet Sugar Coop and Minn-Dak Farmers Coop in 2022. This research reinforces that a strategy to layer soil residual herbicides, starting at planting, is our best program for controlling waterhemp in sugarbeet. Finally, this research demonstrated excellent sugarbeet safety from the chloroacetamide herbicides, that the three chloroacetamide herbicides available in sugarbeet are equally effective at providing waterhemp control, and that the differences in waterhemp control among chloroacetamide products are minor.