

CONTROLLING WATERHEMP IN FIELDS PLANTED TO SUGARBEET

Thomas J. Peters¹, Aaron L. Carlson² and James Rademacher³

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

Summary

1. The most consistent control of waterhemp can be achieved by preemergence (PRE) or preplant incorporated (PPI) herbicide applications followed by (fb) 2 to 3 postemergence (POST) applications of glyphosate plus ethofumesate.
2. For waterhemp control in fields with light infestations, apply glyphosate at 0.98 lb ae/A (equivalent to Roundup PowerMax at 28 fl oz/A) plus ethofumesate at 4 fl oz/A plus a high surfactant methylated seed oil concentrate (HSMOC) at 1.5 pt/A plus ammonium sulfate (AMS) when waterhemp are one to 1.5-inches tall. Make a repeat application approximately 14-days later and as needed when new weeds emerge.
3. For POST and residual control of waterhemp in fields with moderate level infestations or glyphosate-resistant biotypes, apply Dual Magnum, Warrant, or Outlook (or generic equivalents) in combination with glyphosate plus ethofumesate plus HSMOC plus AMS. Sugarbeet must be 2-leaf or larger at application as required by the herbicide labels and precipitation is needed to activate the residual (lay-by) herbicide. Make a repeat POST application of glyphosate plus ethofumesate plus HSMOC plus AMS approximately 14-days later and as needed when new weeds emerge.
4. For control of waterhemp in fields with moderate to heavy level infestations or glyphosate-resistant biotypes, apply Dual Magnum at 0.5 to 0.75 pt/A (use 0.75 pt/A on higher organic matter soils) or ethofumesate at 7 pt/A PRE soon after planting followed by POST glyphosate plus ethofumesate plus HSMOC plus AMS when waterhemp are one to 1.5 inches tall. Make a repeat POST application approximately 14-days later and as needed when new weeds emerge.

Introduction

Waterhemp is an important weed in crop production in many regions of the country including fields rotated to sugarbeet in Minnesota and eastern North Dakota. Waterhemp is a member of the pigweed (Amaranth) family, which includes crops (grain amaranths) and several weedy species including redroot pigweed, powell pigweed, and palmer amaranth. Waterhemp is a summer annual weed that germinates much later than other pigweed species, in mid to late June and July in fields in North Dakota and Minnesota. Waterhemp can germinate and emerge from the soil surface or up to one-half inch deep in the soil and seed can remain viable for at least four years in soil. A unique feature about waterhemp is male and female flowers are found on separate plants (dioecious). That is, a male plant that produces pollen and a female plant that makes seed. This unique biology creates tremendous genetic diversity in populations which results in plants that are biologically and morphologically unique. It also has contributed to development of biotypes that are resistant to several families of herbicides including ALS, triazine, PPO and glyphosate.

Waterhemp's competitive advantage lies in its ability to produce tremendous amounts of seed that potentially germinate and emerge after farmers have completed postemergence herbicide application. Experiments indicate waterhemp can produce from 140,000 to 400,000 seeds per plant depending on timing of emergence and crop competition in fields. A few weed escapes in year one can lead to a severe weed problem in the field by year three. The diversity of biotypes has led to populations that have differential glyphosate tolerance. Control of susceptible selections and failure to control more tolerant selections very quickly can lead to weed shifts that will result in the Roundup-Ready system being less effective or ineffective in fields planted to sugarbeet.

Experiments have been conducted and summarized in these research reports since 2010 to learn more about control of waterhemp. The objective of 2014 experiments was to develop recommendations for a 'systems approach' for control of waterhemp in fields planted to sugarbeet.

Materials and Methods

Experiments were conducted on natural populations of waterhemp near Herman, Minnesota in 2014. Plot area was worked by the cooperating farmer with a John Deere field cultivator equipped with rolling baskets on May 29, 2014. 'Crystal 981RR' sugarbeet was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on May 30.

Sugarbeet was treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams ai, and 5.07 fl oz of product, respectively, per 100,000 seeds. Herbicide treatments were applied May 30, June 23, and July 2 and 10. All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO₂ at 40 psi to the center four rows of six row plots 30 feet in length in a field with moderate to heavy levels of glyphosate-resistant waterhemp. Ammonium sulfate (AMS) in all treatments was a liquid formulation from Winfield Solutions called N-Pak AMS.

Sugarbeet injury was evaluated on June 23 and July 2 and 10. Weed control was evaluated June 23, July 2 and 10, and August 27. All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 9.2014.2 software package.

An experiment was also conducted near Prosper, North Dakota in 2014 to evaluate the effect of lay-by Outlook following preemergence herbicides on sugarbeet injury. Plot area was worked with a 'c-tine' field cultivator equipped with a spring tooth harrow on May 17, 2014. 'SES 36272RR' sugarbeet was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on May 17. Sugarbeet was treated with Tachigaren, Kabina, and NipsIt Suite at 20 grams product, 7 grams ai, and 3.4619 fl oz product, respectively, per 100,000 seeds. Counter 20G at 8.9 lb/A was applied in a band at planting for insect control. 32-10-10 fertilizer was broadcast perpendicular to plots at 143 lb/A on June 18. Herbicide treatments were applied May 17, June 9, and June 24. All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO₂ at 40 psi to the center four rows of six row plots 30 feet in length. Ammonium sulfate in all treatments was a liquid formulation from Winfield Solutions called N-Pak AMS.

Sugarbeet injury was evaluated on June 3, 9, 17, 27, and July 24. All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 9.2014.2 software package.

Table 1. Application information for sugarbeet trials near Herman, MN in 2014.

Application code	A	B	C	D	E
Date	May 30	May 30	June 23	July 2	July 10
Time of Day	10:30 AM	11:00 AM	12:30 PM	10:45 AM	9:45 AM
Air Temperature (F)	86	87	78	64	75
Relative Humidity (%)	46	46	48	55	47
Wind Velocity (mph)	10	10	8	9	6
Wind Direction	S	S	W	WNW	SE
Soil Temp. (F at 6")	66	66	72	58	69
Soil Moisture	Good	Good	Slightly Wet	Good	Good
Cloud Cover (%)	60	60	50	5	5
Sugarbeet stage (avg)	PPI	PRE	4.5 lf	8 lf	12 lf
Waterhemp (untreated avg)	-	-	2.5"	5"	11"

Table 2. Application information for sugarbeet trial near Prosper, ND in 2014.

Application code	A	B	C
Date	May 17	June 9	June 24
Time of Day	3:30 PM	3:15 PM	1:00 PM
Air Temperature (F)	70	77	67
Relative Humidity (%)	32	28	68
Wind Velocity (mph)	8	9	7
Wind Direction	NW	NW	NW
Soil Temp. (F at 6")	45	69	66
Soil Moisture	Good	Good	Good
Cloud Cover (%)	80	25	100
Sugarbeet stage (avg)	PRE	4 lf	8 lf

Results and Discussion

Postemergence Control of Waterhemp

Sugarbeet injury was negligible when Roundup PowerMax (glyphosate) was applied alone or when applied with ethofumesate, Betamix, UpBeet, or Stinger (Table 2). However, glyphosate plus two-way combinations of these herbicides caused visual growth reduction injury. Glyphosate plus UpBeet plus Stinger caused the greatest numerical sugarbeet injury but injury was statistically similar to glyphosate plus the other two-way combinations. Sugarbeet injury decreased over time and generally was not observed 56 or 89 days after planting (data not presented).

Table 2. Sugarbeet injury and waterhemp control from postemergence herbicide treatments, Herman, MN, 2014.

Treatment ¹	Rate fl oz/A or oz/A	Application Code ²	Sgbt injury		Waterhemp control			
			Jun 23	Jul 10	Jun 23	Jul 10	Jul 25	Aug 27
			-----%-----					
PMax ³ / PMax / PMax	32 / 24 / 22	C / D / E	0	0	71	61	64	36
PMax / PMax / PMax	28 / 28 / 22	C / D / E	1	0	66	56	58	21
PMax+Etho / PMax+Etho / PMax+Etho	28+4 / 28+4 / 22+4	C / D / E	6	4	81	76	78	58
PMax+Bmix / PMax+Bmix / PMax+Bmix	28+10 / 28+16 / 22+24	C / D / E	3	6	75	76	79	65
PMax+UpB / PMax+UpB / PMax+UpB	28+0.75 / 28+0.75 / 22+0.75	C / D / E	10	6	86	78	73	51
PMax+Sting / PMax+Sting / PMax+Sting	28+2 / 28+2 / 22+2	C / D / E	8	1	68	53	60	31
PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	28+4+10 / 28+4+16 / 22+4+24	C / D / E	8	13	79	84	85	69
PMax+Etho+UpB / PMax+Etho+UpB / PMax+Etho+UpB	28+4+0.75 / 28+4+0.75 / 22+4+0.75	C / D / E	14	11	81	78	79	64
PMax+Etho+Sting / PMax+Etho+Sting / PMax+Etho+Sting	28+4+2 / 28+4+2 / 22+4+2	C / D / E	13	9	79	72	76	65
PMax+Bmix+Sting / PMax+Bmix+Sting / PMax+Bmix+Sting	28+10+2 / 28+16+2 / 22+24+2	C / D / E	8	10	71	70	74	61
PMax+Bmix+UpB / PMax+Bmix+UpB / PMax+Bmix+UpB	28+10+0.75 / 28+16+0.75 / 22+24+0.75	C / D / E	9	10	80	80	78	64
PMax+UpB+Sting / PMax+UpB+Sting / PMax+UpB+Sting	28+0.75+2 / 28+0.75+2 / 22+0.75+2	C / D / E	21	16	82	68	67	53
LSD (0.05)			7	8	6	6	7	20

¹Treatments of Roundup PowerMax or Roundup PowerMax plus Stinger contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.

²Application codes refer to the information in Table 1.

³PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8; UpB=UpBeet; Sting=Stinger.

Waterhemp control generally was greatest from glyphosate plus ethofumesate plus UpBeet, glyphosate plus ethofumesate plus Betamix, or glyphosate plus Betamix plus UpBeet (Table 2). Of these treatments, glyphosate plus ethofumesate plus Betamix gave greatest numeric control, especially over time. However, none of the postemergence herbicide treatments evaluated provided commercially-acceptable or season-long waterhemp control.

Roundup PowerMax at 32 fb 24 fb 22 fl oz/A gave waterhemp control similar to PowerMax at 28 fb 28 fb 22 fl oz/A. Waterhemp control was inadequate from both glyphosate-only treatments. The experimental area contained a uniform and heavy waterhemp pressure. Stand counts before herbicide application indicated 430 waterhemp plants per square

meter. Most sugarbeet producing areas received excess rainfall in June and Herman, MN was no exception. Excessive precipitation prevented POST applications at one inch waterhemp. Rather, waterhemp was two to three inches tall on average when herbicides treatments were initiated. That stated, the glyphosate weed control system controlled many, but not all, waterhemp plants. The remaining plants, which presumably were resistant biotypes, contributed to a weed-control failure at harvest.

In this experiment glyphosate alone gave less waterhemp control than glyphosate tank-mixed with most broadleaf sugarbeet herbicides. Ethofumesate at 4 fl oz/A applied in combination with glyphosate increased waterhemp control compared to glyphosate alone by 15% on June 23 to 42% on August 29. Based upon these data and data from trials conducted in 2013, we recommend that ethofumesate at 4 fl oz/A plus a HSMOC at 1.5 pt/A plus AMS be added to glyphosate when waterhemp is present in sugarbeet.

Stinger frequently is combined with glyphosate to provide control of common and giant ragweed. Results from other experiments indicated Stinger does not antagonize glyphosate in controlling redroot pigweed or common lambsquarters. However, in this experiment, waterhemp control from Stinger plus glyphosate tended to be less, especially early in the season, than glyphosate alone.

The results from this trial indicate a postemergence program does not provide season-long waterhemp control especially in fields known to contain glyphosate resistant waterhemp biotypes. We recommend the following if there is waterhemp in sugarbeet fields sprayed with postemergence herbicides:

- For light waterhemp infestations apply glyphosate at 0.98 lb ae/A plus ethofumesate at 4 fl oz/A plus HSMOC at 1.5 pt/A plus AMS. Scout fields and make a repeat application approximately 14 days later.
- For moderate waterhemp infestation or waterhemp populations with low level resistance to glyphosate, apply glyphosate at 0.98 lb ae/A plus ethofumesate at 4 fl oz/A plus Betamix (rate dependent on sugarbeet growth stage) plus HSMOC plus AMS.
- For heavy waterhemp infestations or waterhemp populations with moderate to high level resistance to glyphosate, a postemergence alone system should be avoided.

Soil-Applied Herbicides for Waterhemp Control

All soil-applied herbicide treatments were followed by three applications of Roundup PowerMax (glyphosate) at 28 fb 28 fl oz/A. For convenience, discussion will pertain to the soil-applied component of the herbicide treatment and not the postemergence component unless discussing the glyphosate-only treatment.

Sugarbeet growers generally do not use Dual Magnum for PRE grass and broadleaf control in sugarbeet. This is due to sugarbeet stand loss concerns in cool and prolonged wet soils following herbicide application. Dual Magnum was applied at rates from 1.5 to 2 pt/A when it was first registered for use in sugarbeet in the early 2000s. However, rates evaluated in this experiment ranged from 0.5 to 2 pt/A in an effort to find a balance between crop safety and satisfactory weed control.

Sugarbeet injury was negligible from Ro-Neet SB, ethofumesate, glyphosate alone, Dual Magnum at 0.5 and 0.75 pt/A or Dual Magnum at 0.5 pt/A plus ethofumesate at 3, 4 or 5 pt/A (Table 3). However, Dual Magnum at 1 and 2 pt/A or Dual Magnum at 1 pt/A plus ethofumesate at 3, 4 or 5 pt/A caused sugarbeet stand loss or visual growth reduction on the June 23 evaluations.

Ro-Neet at 5.3 pt/A or Dual Magnum at 0.5 to 2 pt/A generally gave greater waterhemp control compared to ethofumesate applied PPI or PRE at 6 pt/A (Table 3). Ethofumesate plus Dual Magnum gave more consistent waterhemp control throughout the season compared to Dual at 0.5 pt/A. However, there was no significant difference in waterhemp control from Dual at 0.5 pt/A compared to Dual at 0.5 pt/A + ethofumesate at either 3, 4, or 5 pt/A. Waterhemp control from PRE Dual Magnum increased as herbicide rate increased. Roundup PowerMax applied three times, in the absence of a soil-applied herbicide, provided 33% waterhemp control in this experiment and was not commercially acceptable.

For waterhemp control in moderate to heavy waterhemp infestations or in fields with confirmed glyphosate-resistant biotypes, apply Dual Magnum at 0.5 to 0.75 pt/A preemergence at planting (use 0.75 pt/A on higher organic matter soils). Consider Dual at 0.5 pt/A plus ethofumesate in medium or fine textured soils or in fields with high organic matter. Make POST applications of glyphosate plus ethofumesate plus AMS plus HSMOC when waterhemp are 1 to 2 inches tall and make repeat applications on approximately 14-day intervals or as needed when new weeds emerge.

Table 3. Sugarbeet injury and waterhemp control from soil-applied herbicides followed by glyphosate Herman, MN, 2014.

Treatment ¹	Rate	Application Code ²	Sugarbeet			Waterhemp Control			
			Stand Jun 23	Injury Jun 23	Injury Jul 10	Jun 23	Jul 2	Jul 10	Aug 27
	pt/A		#/100 ⁷	-----%-----					
Ro-Neet SB	5.3	A	165	8	3	93	97	93	91
Ethofumesate 4SC	6	A	153	8	0	78	90	86	74
Ethofumesate 4SC	6	B	154	3	3	88	88	86	70
Dual Magnum	0.5	B	161	6	0	89	96	95	89
Dual Magnum	0.75	B	154	9	0	89	98	98	94
Dual Magnum	1	B	153	9	10	98	100	100	100
Dual Magnum	2	B	143	10	6	100	100	100	99
Dual+Etho ³	0.5+3	B	152	3	9	99	99	97	94
Dual+Etho	0.5+4	B	161	5	3	98	97	97	94
Dual+Etho	0.5+5	B	158	8	4	100	100	99	96
Dual+Etho	1+3	B	135	16	18	98	100	100	98
Dual+Etho	1+4	B	139	14	16	100	100	100	98
Dual+Etho	1+5	B	134	18	15	98	100	100	96
No soil Herbicide			164	- ⁴	18	-	70	66	33
LSD (0.05)			19	8	8	10	4	4	9

¹Treatments all included Roundup PowerMax at 28 fl oz fb 28 fl oz fb 22 fl oz/A + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v applied on application codes C, D, E.

²Application codes refer to information found in Table 1.

³Dual+Etho=Dual Magunm+Ethofumesate 4SC.

⁴- = no evaluation was made for this treatment, therefore no data were included in analysis.

Lay-by Control of Waterhemp

Sugarbeet injury was negligible from herbicide treatments in this experiment (Table 4). Sugarbeet was at the 4-leaf stage when herbicide treatments were applied. Manufacturers' labels indicate lay-by application of Dual Magnum, Outlook or Warrant be made to 2- to 8-leaf sugarbeet with 4-to 8- leaf sugarbeet being ideal. These herbicide labels clearly state that emerged weeds will not be controlled and that precipitation is required to activate the herbicides. Thus, controlling emerged weeds with POST herbicides and properly timing lay-by applications prior to weed emergence is vital for the concept of lay-by herbicides to be implemented successfully.

The June 23 application of Roundup PowerMax at 28 fl oz/A controlled 78% of emerged waterhemp based on waterhemp counts taken immediately prior to and 9 days following application (count data not presented). However, waterhemp that were not controlled by this and subsequent applications of PowerMax became a season-long weed control challenge that resulted in only 35% waterhemp control on August 27 (Table 4). The addition of ethofumesate at 4 fl oz/A plus HSMOC to glyphosate improved waterhemp control 40% compared to glyphosate alone on August 27. Based on 2013 and 2014 experiments, we recommend ethofumesate at 4 fl oz/A plus HSMOC be added to glyphosate when waterhemp is a target weed in sugarbeet.

Dual Magnum, Warrant and Outlook applied in combination with glyphosate and ethofumesate gave similar waterhemp control. Dual Magnum at 1 pt/A, Warrant at 3 pt/A, and Outlook at 12 fl oz/A applied in combination with glyphosate and ethofumesate and fb two applications of glyphosate plus ethofumesate gave 90%, 84%, and 94% waterhemp control respectively on August 27. Waterhemp control from these treatments tended to increase as the season progressed, presumably due to the residual weed control offered by Dual Magnum, Warrant or Outlook. However, Dual Magnum, Warrant, and Outlook applied with glyphosate alone and fb two applications of glyphosate alone gave only 40%, 36%, and 59% waterhemp control on August 27. Waterhemp control from these treatments tended to decrease as the season progressed due to the inability to control emerged waterhemp with glyphosate alone. These differences illustrate the importance of controlling waterhemp that has emerged prior to lay-by herbicide application.

Herbicides treatments that provided good waterhemp control also provided good control of other grass and broadleaf weeds in the experiment (data not presented). There was no evidence of antagonism of glyphosate activity from herbicides applied in combination with PowerMax.

Table 4. Sugarbeet injury and waterhemp control from lay-by herbicides, ethofumesate, and glyphosate, Herman, MN, 2014.

Treatment ¹	Rate	Application Code ²	Sugarbeet Injury		Waterhemp Control			
			Jul 2	Jul 10	Jul 2	Jul 10	Jul 25	Aug 27
	fl oz or pt/A		-----%-----					
PMax ³ / PMax / PMax	28 / 28 / 22	C/D/E	1	3	61	60	61	35
PMax+Etho /	28+4 /	C /						
PMax+Etho / PMax+Etho	28+4 / 22+4	D / E	3	8	68	76	78	75
PMax+Dual /	28+1pt /	C /						
PMax / PMax	28 / 22	D / E	0	4	68	68	65	40
PMax+Etho+Dual /	28+4+1pt /	C /						
PMax+Etho / PMax+Etho	28+4 / 22+4	D / E	3	5	76	84	85	90
PMax+Dual /	28+1.6pt /	C /						
PMax / PMax	28 / 22	D / E	4	9	75	73	65	45
PMax+Warrant /	28+3pt /	C /						
PMax / PMax	28 / 22	D / E	1	5	70	63	64	36
PMax+Etho+Warrant /	28+4+3pt /	C /						
PMax+Etho / PMax+Etho	28+4 / 22+4	D / E	8	11	75	83	87	84
PMax+Warrant /	28+4pt /	C /						
PMax / PMax	28 / 22	D / E	5	4	66	65	66	49
PMax+Outlook /	28+12 /	C /						
PMax / PMax	28 / 22	D / E	3	4	80	72	70	59
PMax+Etho+Outlook /	28+4+12 /	C /						
PMax+Etho / PMax+Etho	28+4 / 22+4	D / E	1	3	83	89	87	94
PMax+Outlook /	28+21 /	C /						
PMax / PMax	28 / 22	D / E	4	9	75	73	68	45
LSD (0.05)			NS	NS	12	11	9	20

¹Applications of Roundup PowerMax plus ethofumesate contained N-Pak AMS at 2.5% v/v plus Destiny HC at 1.5pt/A. All other applications contained N-Pak AMS at 2.5% v/v plus Prefer 90 NIS at 0.25% v/v.

²Application codes refer to the information in Table 1.

³PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Dual=Dual Magnum.

Based on results from this experiment, we believe lay-by herbicides provide an excellent tool for control of moderate infestations of waterhemp. Emerged weeds can pose a risk to the lay-by system and must be controlled with glyphosate plus ethofumesate or other postemergence herbicides. Precipitation is also required to activate the lay-by herbicides. Dual Magnum, Warrant, and Outlook provided similar control in this experiment. The decision on which product to apply should be based on other factors than waterhemp control.

Preemergence followed by Lay-by Herbicides in Sugarbeet

Waterhemp can emerge throughout the season and some researchers have found ‘layering’ residual herbicides an effective strategy for providing season-long waterhemp control. In sugarbeet, however, there are concerns of crop safety from layering preemergence and lay-by residual herbicides. Preemergence ethofumesate alone is relatively safe on sugarbeet, but concerns have been raised about applying lay-by herbicides in addition to PRE ethofumesate and the potential for unacceptable levels of sugarbeet injury, especially on medium to coarse textured soils.

Experiments were conducted near Prosper, ND, in 2014 to investigate the effect of preemergence soil-applied herbicides fb glyphosate compared to fb glyphosate plus Outlook on sugarbeet injury, yield, and quality. Ethofumesate, Dual Magnum, and ethofumesate plus Dual Magnum were applied preemergence and fb two applications of Outlook at 12 fl oz/A plus glyphosate. Sugarbeet stand and visual injury evaluations were collected over time in the experiment and sugarbeet root yield and quality were also evaluated.

Preemergence Dual Magnum at 1.5 pt/A and PRE Dual Magnum at 1.5 pt/A fb glyphosate plus Outlook reduced sugarbeet stand at harvest compared to glyphosate alone (Table 5). This reduction in stand can most likely be attributed to PRE Dual Magnum. There were no differences, however, among any treatments in sugarbeet yield or quality. Sugarbeet visual injury tended to be greatest from Dual Magnum at 1.5 pint/A or Dual Magnum at 1.5 pint/A followed by Outlook and ethofumesate followed by Outlook (Table 6). However, statistical analysis was not performed on the data in Table 6 meaning no statistical comparisons can be made.

Table 5. Effect of preemergence herbicides followed by lay-by Outlook on sugarbeet stand, yield, and quality at Prosper, ND, 2014.

Treatment ¹	Rate	Application Code ²	Jun 17	September 3			
			Stand	Stand	Yield	Sugar	Sucrose
	fl oz or pt/A		#/100'	#/100'	ton/A	%	lb/A
PMax / PMax	28 / 28	B / C	189	161	28.9	13.9	7173
PMax+Outlook / PMax+Outlook	28+12 / 28+12	B / C	186	154	30.6	14.0	7770
Ethofumesate 4SC / PMax / PMax	7.5pt	A	182	154	29.9	14.2	7665
Ethofumesate 4SC / PMax+Outlook / PMax+Outlook	7.5pt	A	180	151	28.3	14.2	7348
Dual Magnum / PMax / PMax	0.75pt	A	174	157	29.7	14.0	7418
Dual Magnum / PMax+Outlook / PMax+Outlook	0.75pt	A	181	159	28.2	14.7	7636
Dual Magnum / PMax / PMax	1.5pt	A	145	129	29.1	13.7	7106
Dual Magnum / PMax+Outlook / PMax+Outlook	1.5pt	A	155	138	29.5	14.4	7703
Ethofumesate 4SC+Dual Magnum / PMax / PMax	3pt+1pt	A	171	141	30.1	13.8	7449
Ethofumesate 4SC+Dual Magnum / PMax+Outlook / PMax+Outlook	3pt+1pt	A	155	131	28.8	14.6	7713
LSD (P=.05)			22	18	NS	NS	NS

¹Applications of Roundup PowerMax plus ethofumesate contained N-Pak AMS at 2.5% v/v plus Destiny HC at 1.5pt/A. All other applications contained N-Pak AMS at 2.5% v/v plus Prefer 90 NIS at 0.25% v/v.

²Application codes refer to the information in Table 1.

³PMax=Roundup PowerMax.

Table 6. Average visual sugarbeet injury over time from preemergence herbicides followed by lay-by Outlook at Prosper, ND, 2014.

Preemergence (PRE) Treatment	Rate	PRE Treatment Alone	PRE followed by Outlook
	pt/A	-----% sugarbeet injury-----	
None		4	9
Ethofumesate 4SC	7.5	10	21
Dual Magnum	0.75	14	10
Dual Magnum	1.5	21	20
Ethofumesate 4SC + Dual Magnum	3 + 0.75	12	17

Data from this trial suggest that layering soil residual herbicides as a PRE herbicide followed by a lay-by herbicide may be safe in sugarbeet. This strategy might be a viable option for controlling heavy infestations of glyphosate resistant waterhemp and future trials will investigate waterhemp control using this strategy. As a reminder, this data is based off of one year and one location of research and should be viewed as preliminary.

Future Research

The treatments presented in this article will be evaluated again in 2015 as well as investigation into low rates of PRE Dual Magnum fb lay-by applications of Dual Magnum, Warrant, or Outlook in combination with glyphosate and ethofumesate to extend residual activity on waterhemp. Future research will also investigate split applications of Dual Magnum, Warrant or Outlook applied lay-by to extend residual activity on waterhemp. Additional research may also be conducted to evaluate adjuvants to apply with POST glyphosate plus ethofumesate for waterhemp control.