Gold Section: **Sugarbeet Weed Control** Page

FEATURED WEED – COMMON RAGWEED
CONTROLLING COMMON RAGWEED IN FIELDS PLANTED TO SUGARBEET

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Summary

1. For common ragweed control in fields with biotypes that are moderately resistant to glyphosate and are less than one-inch tall, spray glyphosate at 0.98 lb ae/A (equivalent to Roundup PowerMax at 28 fl oz/A) plus Stinger at 2 fl oz/A. Make a repeat application approximately 14 days following the first application.
2. For common ragweed control in fields with biotypes that are moderately resistant to glyphosate and are less than two-inches tall, spray glyphosate at 0.98 lb ae/A plus Stinger at 3 fl oz/A. Make a repeat application approximately 14 days following the first application.
3. For common ragweed control in fields with moderate level infestations or in fields with glyphosate resistant biotypes that are up to four-inches tall, spray glyphosate at 0.98 lb ae/A plus Stinger at 4 fl oz/A or glyphosate at 0.98 lb ae/A plus Stinger at 2 oz/A plus either ethofumesate at 4 fl oz/A, UpBeet at 0.5 oz/A or Betamix at 12 fl oz/A plus a high surfactant methylated seed oil conenctrate (HSMOC) at 1.5 pt/A. Make a repeat application approximately 14 days following the first application.
4. Stinger at 2 fl oz/A followed by Stinger at 2 fl oz/A will not cause significant injury to cotlyledon to two-leaf sugarbeet. However, there will be visual injury from Stinger at 4 fl oz/A followed Stinger at 4 fl oz/A, especially when the first application is over cotyledon to 2-leaf sugarbeet.
5. Stinger will not antagonize control of foxtail species, redroot pigweed, or common lambsquarters but may antagonize control of waterhemp from glyphosate.

Introduction

Common ragweed is a summer annual broadleaf weed in the composite family. Common ragweed germinates and emerges from April through May on or very near the soil surface and returns to dormancy once hot temperatures arrive during late June, July and August. Common ragweed is frequently found in pastures and along ditches or waterways but is also common in corn and soybean fields in the upper Midwest, especially in fields where reduced-tillage or no-tillage systems are practiced. Common ragweed is synonymous with allergies including 'hay fever' due to the great amount of pollen it produces, as many as one billion grains of pollen per plant during the year.

Common ragweed cotyledons are spoon shaped or nearly round and are somewhat thickened. The true leaves have a very distinct shape, that tell-tale phenotype we have observed on so many occasions in fields. Leaves have one or two deep clefts, forming lobes in each margin that are slightly pointed at the tips. Short, whitish hairs cover the leaves and stem and are most dense on the lower leaf surfaces. Male and female flowers are in separate heads on the same plant. Plants produce between 30,000 and 60,000 seeds per plants that range from three to six feet in height.

Common ragweed is found in all factory districts in Minnesota and North Dakota. Proper control requires a prolonged strategy that includes cultural, mechanical and chemical control options. Mowing can be effective in ditches and grass waterways provided mowing is done on a regular basis. Two-inch common ragweed can grow back if cut above the seed leaves, and ragweed mowed in midsummer can grow new stems and flower only ten days later than plants that are not mowed. Seeds are extremely long-lived in soils, potentially remaining viable for over 30 years. The longevity of common ragweed seeds enables the weed to counteract the effects of tillage, which decreases but does not eradicate the ragweed population. Small grains are an excellent crop in soils infested with ragweed as early planted and emerging crops have a competitive advantage over ragweed. In addition, many cereals herbicides are effective on common ragweed. Several soil-applied herbicides have activity on common ragweed in corn and soybean production.

Materials and Methods

Experiments were conducted on natural populations of common ragweed near Mayville, North Dakota in 2014. Plot area was worked with a Kongskilde 's-tine' field cultivator equipped with rolling baskets on May 21, 2014. 'SES

36272RR' sugarbeet was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on May 21. 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. Herbicide treatments were applied June 10, 18, 24 and 26, and July 7 and 18. All 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 30 feet in length in a field with moderate to heavy levels of glyphosate-resistant common ragweed. Ammonium sulfate in all treatments was a liquid formulation from Winfield Solutions called N-Pak AMS.

Sugarbeet injury was evaluated on June 17 and 25 and July 7 and 14. Weed control was evaluated June 17 and 25, July 7, 14 and 25. 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

Application code	**A**	**B**	**C**	**D**	**E**	**F**
Date	June 10	June 18	June 24	June 26	July 7	July 18
Time of Day	12:20 PM	9:00 AM	9:30 AM	12:00 PM	9:15 AM	1:00 PM
Air Temperature (F)	77	66	60	66	73	79
Relative Humidity (%)	32	61	79	71	56	53
Wind Velocity (mph)	6	8	10	4	7	10
Wind Direction	SW	E	N	SE	NW	S
Soil Temp. (F at 6")	72	63	68	65	70	76
Soil Moisture	Good	Good	Good	Good	Good	Good
Cloud Cover (%)	60	75	100	90	10	5
Sugarbeet stage (avg)	cot-2lf	2-4 lf	4-6 lf	4-7 lf	4-8 lf	7-11 lf
Ragweed (untreated avg)	¾"	2"	4"	4"	6"	10"

Results and Discussion

Sugarbeet Injury - Visual sugarbeet injury from herbicide treatments was generally negligible in this experiment (Table 2). Visual injury was greatest when herbicide treatments were applied to 4-inch common ragweed. However, visual injury likely was caused by weed competition rather than herbicides. The experimental area was a sandy loam soil with a low water holding capacity. A heavy green foxtail infestation caused competition damage to sugarbeet which likely caused the visual growth reduction.

There were minor differences in sugarbeet injury among treatments within application timings (i.e. 1", 2", and 4"). Sugarbeet injury tended to be greatest from sequential applications of Roundup PowerMax (glyphosate) plus Stinger at 4 fl oz/A. Stinger caused noteworthy injury when applied to cotyledon to 2-leaf sugarbeet and common ragweed less than one inch tall. Trials were conducted in 2009 and 2010 where Stinger was applied up to 8 fl oz/A to 2-leaf sugarbeet. Sugarbeet injury in those trials tended to be greatest from sequential 4 fl oz applications or from a single 8 fl oz/A application (data not presented). However, injury was not consistent and tended to decrease over time. Yield results from the 2010 experiments were inconsistent but indicated there was no loss of sugarbeet yield.

Common Ragweed Control - Herbicide treatments applied to one-inch common ragweed tended to provide better control than treatments applied to two-inch or four-inch common ragweed (Table 2). Herbicide treatments containing Stinger improved common ragweed control compared to glyphosate alone. Improved ragweed control was most dramatic when Stinger was applied to common ragweed up to one-inch tall. When applied to these small weeds, glyphosate alone, averaged across rates and timings, gave 68% common ragweed control compared to 95% control from glyphosate plus Stinger. These results indicate the field contained some glyphosate resistant common ragweed biotypes. The magnitude of common ragweed control between glyphosate alone and glyphosate plus Stinger decreased as common ragweed size increased. When treatments were applied to common ragweed up to two- and four-inches tall, averaged across treatments, glyphosate plus Stinger improved common ragweed control by 24% on two-inch ragweed and 7% on four-inch ragweed compared to glyphosate alone.

Table 2. Sugarbeet injury and common ragweed control near Mayville, ND in 2014.

Treatment[1]	Rate	Application code[2]	June 25 sgbt inj	July 7 sgbt inj	July 7 cora cntl	July 14 cora cntl	July 25 cora cntl
	fl oz/A		----------%----------				
Up to 1" common ragweed							
PMax[3] / PMax	28 / 28	A / D	3	1	80	70	64
PMax / PMax	32 / 24	A / D	8	3	79	67	63
PMax / PMax / PMax	28 / 28 / 22	A / C / E	4	1	74	74	76
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	A / C / E	0	3	89	88	92
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	A / C / E	9	9	95	95	95
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	A / C / E	6	1	93	92	97
Up to 2" common ragweed							
PMax / PMax	28 / 28	B / D	8	13	87	79	69
PMax / PMax	32 / 24	B / D	15	15	75	67	61
PMax / PMax / PMax	28 / 28 / 22	B / D / F	8	11	81	76	75
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	B / D / F	13	14	84	83	89
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	B / D / F	3	13	84	84	93
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	B / D / F	8	11	90	87	93
Up to 4" common ragweed							
PMax / PMax	28 / 28	D / E		34	63	66	79
PMax / PMax	32 / 24	D / E		35	66	66	78
PMax / PMax / PMax	28 / 28 / 22	D / E / F		24	64	68	82
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	D / E / F		24	59	72	84
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	D / E / F		29	63	76	91
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	D / E / F		36	61	67	84
LSD (0.05)			**NS**	**10**	**14**	**14**	**11**

[1]All treatments were applied with N-Pak AMS at 2.5% v/v and Prefer 90 NIS at 0.25% v/v
[2]Application information is listed in Table 1
[3]PMax=Roundup PowerMax

1" Or Smaller Common Ragweed - There were no differences in common ragweed control among treatments containing Stinger when applied in combination with glyphosate to one inch common ragweed (Table 2). Even though control tended to be best from glyphosate plus Stinger at 4 fl oz/A, this combination showed a tendency toward increased sugarbeet injury. There was no difference in common ragweed control from Roundup PowerMax at 28 fl oz/A followed by 28 fl oz/A compared to Roundup PowerMax at 32 fl oz/A followed by 24 fl oz/A at any application timings. Our recommendations are to use the greatest glyphosate rate based on weed species and weed size in the field. Since most sugarbeet growers use at least a two-spray weed control program in sugarbeet, it seems logical to apply equal rates of glyphosate in both the first and second applications.

The three-spray glyphosate alone program tended to improve common ragweed control compared to the two-spray program, especially at the late evaluation timing. We attributed this to the low moisture holding content of the soil and the overall slow growth of sugarbeet at this location.

2" Or Smaller Common Ragweed - Ragweed control tended to be greater when combinations of glyphosate and Stinger at 4 fl oz/A were followed by either Stinger at 4 fl oz/A or sequential applications of Stinger at 2 fl oz/A and applied to two-inch ragweed compared to glyphosate alone or glyphosate plus Stinger at 2 fl oz/A (Table 2). However, control was not statistically significant or consistent across herbicide treatments. Overall, as ragweed size at the initial application increased, control decreased.

4" Common Ragweed - Common ragweed control ranged from 78% to 91% control when herbicide treatments were initiated on common ragweed up to four inches in size (Table 2). In addition, there was a small response to rate

between glyphosate alone and glyphosate plus Stinger treatments. Glyphosate plus Stinger at 4 fl oz/A applied twice gave the greatest numeric control of common ragweed.

There may be another approach to control common ragweed that has reached four inches in size. An experiment was conducted to evaluate ethofumesate, UpBeet, or Betamix applied in combination with glyphosate plus Stinger. Ragweed control was improved from these combinations compared to glyphosate plus Stinger at 2 fl oz/A. However, there was very little difference in numeric control among treatments (data not shown). Generally ethofumesate, UpBeet, or Betamix combinations caused greater sugarbeet injury than glyphosate plus Stinger. Injury tended to be greatest with UpBeet combinations and least with Betamix and decreased over time.

Other Weeds - The addition of Stinger to glyphosate did not antagonize green foxtail, redroot pigweed, or common lambsquarters control compared to glyphosate alone, regardless of weed size (Table 3). This observation is consistent with results from the 2009 and 2010 trials previously mentioned. However, control was not the same across all herbicide treatments or application timings. The three-spray program provided greater green foxtail and lambsquarters control than the two-spray program, presumably since there was an additional flush of weeds in an open canopy.

Table 3. Green foxtail, redroot pigweed and common lambsquarters control in sugarbeet near Mayville, ND in 2014.

			grfx[3] control		rrpw control		colq control	
Treatment[1]	**Rate (oz/A)**	**Application code[2]**	**June 25**	**July 25**	**June 25**	**July 25**	**June 25**	**July 25**
	fl oz/A		----------%----------					
Up to 1" common ragweed								
PMax[4] / PMax	28 / 28	A / D	94	74	98	95	99	80
PMax / PMax	32 / 24	A / D	94	75	99	93	98	71
PMax / PMax / PMax	28 / 28 / 22	A / C / E	89	93	98	100	99	100
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	A / C / E	95	95	98	100	99	100
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	A / C / E	96	91	99	100	100	100
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	A / C / E	98	95	100	100	100	100
Up to 2" common ragweed								
PMax / PMax	28 / 28	B / D	100	84	100	78	100	73
PMax / PMax	32 / 24	B / D	100	86	100	86	98	85
PMax / PMax / PMax	28 / 28 / 22	B / D / F	100	100	100	100	100	100
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	B / D / F	100	99	100	100	100	99
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	B / D / F	100	98	99	100	100	100
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	B / D / F	100	99	100	100	100	100
Up to 4" common ragweed								
PMax / PMax	28 / 28	D / E	-[5]	93	-	99	-	99
PMax / PMax	32 / 24	D / E	-	94	-	99	-	98
PMax / PMax / PMax	28 / 28 / 22	D / E / F	-	100	-	100	-	100
PMax+Stinger / PMax+Stinger / PMax	28+2 / 28+2 / 22	D / E / F	-	100	-	100	-	100
PMax+Stinger / PMax+Stinger / PMax	28+4 / 28+4 / 22	D / E / F	-	100	-	100	-	100
PMax+Stinger / PMax+Stinger / PMax+Stinger	28+4 / 28+2 / 22+2	D / E / F	-	100	-	100	-	100
LSD (0.05)			**4**	**5**	**NS**	**7**	**NS**	**8**

[1]All treatments were applied with N-Pak AMS at 2.5% v/v and Prefer 90 NIS at 0.25% v/v
[2]Application information is listed in Table 1
[3]grfx=green foxtail; rrpw=redroot pigweed; colq=common lambsquarters
[4]PMax=Roundup PowerMax
[5]- indicates treatments had not been applied at this evaluation and were not included in statistical analysis

CONTROLLING WATERHEMP IN FIELDS PLANTED TO SUGARBEET

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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 HSOMC 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 CO_2 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 CO_2 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.

		Application	Sgbt injury		Waterhemp control			
Treatment[1]	**Rate**	**Code[2]**	**Jun 23**	**Jul 10**	**Jun 23**	**Jul 10**	**Jul 25**	**Aug 27**
	fl oz/A or oz/A		----------%----------					
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**

[1]Treatments 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.
[2]Application codes refer to the information in Table 1.
[3]PMax=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 fb 22 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.

			Sugarbeet			Waterhemp Control			
Treatment[1]	Rate	Application Code[2]	Stand Jun 23	Injury Jun 23	Injury Jul 10	Jun 23	Jul 2	Jul 10	Aug 27
	pt/A		#/100'	----------%----------					
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**

[1]Treatments 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.
[2]Application codes refer to information found in Table 1.
[3]Dual+Etho=Dual Magnum+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.

		Application	Sugarbeet Injury		Waterhemp Control			
Treatment[1]	**Rate**	**Code[2]**	**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 / PMax+Etho / PMax+Etho	28+4 / 28+4 / 22+4	C / D / E	3	8	68	76	78	75
PMax+Dual / PMax / PMax	28+1pt / 28 / 22	C / D / E	0	4	68	68	65	40
PMax+Etho+Dual / PMax+Etho / PMax+Etho	28+4+1pt / 28+4 / 22+4	C / D / E	3	5	76	84	85	90
PMax+Dual / PMax / PMax	28+1.6pt / 28 / 22	C / D / E	4	9	75	73	65	45
PMax+Warrant / PMax / PMax	28+3pt / 28 / 22	C / D / E	1	5	70	63	64	36
PMax+Etho+Warrant / PMax+Etho / PMax+Etho	28+4+3pt / 28+4 / 22+4	C / D / E	8	11	75	83	87	84
PMax+Warrant / PMax / PMax	28+4pt / 28 / 22	C / D / E	5	4	66	65	66	49
PMax+Outlook / PMax / PMax	28+12 / 28 / 22	C / D / E	3	4	80	72	70	59
PMax+Etho+Outlook / PMax+Etho / PMax+Etho	28+4+12 / 28+4 / 22+4	C / D / E	1	3	83	89	87	94
PMax+Outlook / PMax / PMax	28+21 / 28 / 22	C / D / E	4	9	75	73	68	45
LSD (0.05)			**NS**	**NS**	**12**	**11**	**9**	**20**

[1]Applications 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.
[2]Application codes refer to the information in Table 1.
[3]PMax=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 Stand	September 3 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 /	7.5pt	A	182	154	29.9	14.2	7665
PMax / PMax	28 / 28	B / C					
Ethofumesate 4SC /	7.5pt	A	180	151	28.3	14.2	7348
PMax+Outlook / PMax+Outlook	28+12 / 28+12	B / C					
Dual Magnum /	0.75pt	A	174	157	29.7	14.0	7418
PMax / PMax	28 / 28	B / C					
Dual Magnum /	0.75pt	A	181	159	28.2	14.7	7636
PMax+Outlook / PMax+Outlook	28+12 / 28+12	B / C					
Dual Magnum /	1.5pt	A	145	129	29.1	13.7	7106
PMax / PMax	28 / 28	B / C					
Dual Magnum /	1.5pt	A	155	138	29.5	14.4	7703
PMax+Outlook / PMax+Outlook	28+12 / 28+12	B / C					
Ethofumesate 4SC+Dual Magnum /	3pt+1pt	A	171	141	30.1	13.8	7449
PMax / PMax	28 / 28	B / C					
Ethofumesate 4SC+Dual Magnum /	3pt+1pt	A	155	131	28.8	14.6	7713
PMax+Outlook / PMax+Outlook	28+12 / 28+12	B / C					
LSD (P=.05)			**22**	**18**	**NS**	**NS**	**NS**

[1]Applications 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.
[2]Application codes refer to the information in Table 1.
[3]PMax=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.

IMPACT OF SOIL-APPLIED HERBICIDES ON SPRING-SEEDED CEREAL COVER CROP IN SUGARBEET

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Summary

1. Oat is more tolerant of Dual Magnum plus ethofumesate than barley or wheat. Wheat generally was the least tolerant to soil-applied herbicides of the species evaluated.
2. Within species there was a difference in response to herbicide and rate. Dual Magnum generally was safer to cover crop species and ethofumesate more injurious.
3. Sugarbeet injury generally was negligible across herbicide treatments. However, visual sugarbeet injury from ethofumesate at 3pt/A plus Dual Magnum at 1 pt/A or ethofumesate at 3pt/A plus Dual Magnum at 1 pt/A followed by UpBeet at 1 oz/A was greater than from glyphosate alone.

Introduction

The annual survey of sugarbeet farmers in eastern North Dakota and Minnesota indicated spring-seeded cereal cover crops were used on about 44% of sugarbeet acres in 2014 (Table 1). Farmers most commonly plant cover crops to protect sugarbeet from wind and soil erosion during stand establishment. There are other benefits of cover crops. Farmers in Southern Minnesota, in cooperation with the Minnesota Pollution Control Agency (MCPA), grow cover crops in exchange for phosphorus credits. Cover crops suppress weed development since they germinate and emerge much sooner than most weedy species. Cover crops may contribute to maintaining soil quality including soil structure, cycling nutrients and soil fertility. Finally, cover crops may suppress the germination and emergence of weeds.

Table 1. Percent of sugarbeet acres seeded with various cover crops as reported in the annual survey of weed control and production practices in sugarbeet in 2014.

	No. of responses	Acres planted	Barley	Oat	Wheat	Rye	Other	No Response
			% of acres planted					
Cass	7	4,393	23	-	-	-	-	77
Chippewa[1]	14	7,611	-	43	45	-	-	12
Clay[2]	12	7,544	10	10	-	-	-	80
Grand Forks	9	6,009	21	-	-	-	-	79
Kittson	3	920	-	-	-	-	-	100
Marshall	9	6,359	8	-	15	-	-	77
Norman[3]	7	5,278	54	-	6	-	-	41
Pembina	8	5,132	18	12	15	-	-	55
Polk[4]	32	15,301	27	-	4	9	<1	60
Renville[5]	23	11,019	-	59	13	-	-	28
Richland[6]	12	9,101	40	-	35	-	-	25
Traill	3	573	35	-	-	-	-	65
Traverse[7]	13	8,160	13	3	18	-	3	63
Walsh	10	4,382	2	7	30	-	5	56
Wilkin[8]	26	14,168	20	-	3	-	1	76
Total	188	105,950	18	11	13	1	1	56

[1]Includes Kandiyohi and Swift Counties
[2]Includes Becker County
[3]Includes Mahnomen County
[4]Includes Pennington and Red Lake Counties
[5]Includes Lac Qui Parle, McLeod, Redwood, Stearns, and Yellow Medicine Counties
[6]Includes Roberts (SD) County
[7]Includes Grant and Stevens Counties
[8]Includes Otter Tail County

Waterhemp (Amaranthus spp.), has become 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 summer annual weed

that germinates much later than other pigweed species, through mid-to late-June and into July in fields in North Dakota and Minnesota. Some farmers are returning to the use of soil-applied herbicides to control waterhemp, partly due to increased occurrences of glyphosate-resistant waterhemp biotypes. However, little is known about the tolerance of soil-applied herbicides to spring-seeded cereal cover crops that typically are seeded at or shortly ahead of sugarbeet planting. Thus, sugarbeet growers today must decide between using cover crops or soil-applied herbicides, but not both.

The objectives of these field experiments was to investigate barley, oat, and wheat ground cover and sugarbeet safety following preemergence herbicide application.

Materials and Methods

Experiments were conducted near Crookston, Foxhome, Herman, and Lake Lillian, MN in 2014. Barley, oat and wheat cover crops were used individually within an experiment. Hard red spring wheat was chosen for use at Crookston and Herman, barley was used at Foxhome, and oat was selected for Lake Lillian. Small grains were spread perpendicular to plots across the experimental area with a 3-point mounted rotary spreader at between 0.75 and 1 bu/A, depending on specie. Cover crops were shallow incorporated with tillage perpendicular to plots prior to planting sugarbeet. Sugarbeet was seeded approximately 1-inch deep in 22-inch rows at each location. Herbicides were applied to the center four rows of six-row by 30-foot long plots.

All barley, oat, and wheat ground cover and sugarbeet injury evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Sugarbeet stand counts were taken in the center 2 rows of plots and cover crop density was collected by counting emerged small grain in a ¼ square meter quadrat. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 9.2014.2 software package.

Results and Discussion

Oat germinated and emerged similarly through soils treated with Dual Magnum, ethofumesate, and Dual Magnum plus ethofumesate and gave acceptable ground coverage at Lake Lillian (Table 2). There were no difference among the herbicides treatments evaluated or herbicide treatment rates.

Wheat and barley ground cover was dependent on herbicide treatment and rate (Table 2). Dual Magnum generally was safer to wheat and barley than ethofumesate or Dual Magnum plus ethofumesate. Wheat and barley ground coverage was acceptable in plots treated with Dual Magnum and unacceptable in plots treated with ethofumesate or ethofumesate plus Dual Magnum. Generally, as ethofumesate rate increased, regardless of being applied alone or in combination with Dual Magnum, barley and wheat ground cover decreased.

Dual Magnum at 0.5 pt/A gave the greatest wheat ground cover among preemergence herbicide treatments evaluated. At both Crookston and Herman, as Dual rate increased, wheat ground cover decreased. Ground cover in plots treated with Dual Magnum at 1 pt/A was significantly less than the untreated at both Crookston and Herman. Wheat did not tolerate ethofumesate or Dual Magnum plus ethofumesate at either the Crookston or Herman location. Ethofumesate at 2 pt/A was no safer to wheat than ethofumesate at 3 pt/A.

Barley responded to herbicides more similarly to wheat than oat (Table 2). Barley ground cover in plots treated with Dual Magnum at 0.5 pt/A was similar to the untreated plots. However, ground cover in plots treated with Dual Magnum at 1 pt/A was less than with Dual Mangum at 0.5 pt/A. Barley showed some tolerance to ethofumesate or Dual Magnum plus ethofumesate. However, ground cover ranged from 21% to 35% and would not be acceptable to most growers.

Sugarbeet stand counts from these experiments showed no significant differences among treatments (Table 3). Data is presented from the Foxhome, Crookston and the Lake Lillian locations but was not collected at the Herman location due to water ponding resulting from excessive precipitation in June and July. In general, there was more stand loss at the Foxhome location, especially from ethofumesate at 3 pt/A. This might be attributed to the soil type, an Espelie fine sandy loam.

Table 2. Ground cover as a percentage of untreated evaluated 19 to 28 days after planting.

Treatment[1]	Rate	19 DAP[3] Foxhome Barley	28 DAP Crookston Wheat	24 DAP Herman Wheat	24 DAP Lake Lillian Oat
	pt or oz/A	----------% ground cover----------			
Untreated		100	100	100	100
Dual Magnum	0.5	85	75	78	80
Dual Magnum	1	57	62	57	85
Ethofumesate	2	35	27	26	68
Ethofumesate	3	32	25	24	74
Dual + Etho	0.5+2	34	30	31	95
Dual + Etho	1+2	31	20	19	92
Dual + Etho	0.5+3	21	26	14	77
Dual + Etho	1+3	24	21	10	100
Dual + Etho / UpBeet[2]	1+3 / 1oz	29	27	5	84
LSD (0.05)		**16**	**27**	**17**	**NS**

[1]Roundup PowerMax at 28 fl oz/A plus Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v was applied at the sugarbeet 4- to 6-leaf stage and was repeated on approximately 14 day intervals at 28 fl oz/A and 22 fl oz/A for weed control in all treatments including the untreated.
[2]Upbeet at 1 oz/A plus methylated seed oil at 1.5% v/v was applied when sugarbeet were cotyledon to 2-leaf.
[3]DAP=days after planting

Table 3. Sugarbeet stand as percent of untreated evaluated 19 to 28 days after planting.

Treatment[1]	Rate	19 DAP[3] Foxhome	28 DAP Crookston	Herman	24 DAP Jun 17 Lake Lillian
	pt or oz/A	----------% sugarbeet stand----------			
Untreated		100	100	-[4]	100
Dual Magnum	0.5	91	101	-	104
Dual Magnum	1	102	100	-	96
Ethofumesate	2	63	106	-	99
Ethofumesate	3	79	97	-	98
Dual + Etho	0.5+2	92	103	-	100
Dual + Etho	1+2	118	102	-	91
Dual + Etho	0.5+3	104	99	-	94
Dual + Etho	1+3	77	96	-	97
Dual + Etho / UpBeet[2]	1+3 / 1oz	86	103	-	99
LSD (0.05)		**NS**	**NS**	**-**	**NS**

[1]Roundup PowerMax at 28 fl oz/A plus Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v was applied at the sugarbeet 4- to 6-leaf stage and was repeated on approximately 14 day intervals at 28 fl oz/A and 22 fl oz/A for weed control in all treatments including the untreated.
[2]Upbeet at 1 oz/A plus methylated seed oil at 1.5% v/v was applied when sugarbeet were cotyledon to 2-leaf.
[3]DAP=days after planting
[4]- = evaluation not taken

Sugarbeet injury expressed as visual growth reduction injury was collected at Crookston and Herman 27 and 24 days after planting, respectively (Table 4). There was no significant injury at the Herman location. However, there was some injury at Crookston, especially in plots treated with ethofumesate at 3 pt/A and plots treated with ethofumesate plus Dual Magnum. Injury was noted as visual stature reduction. Ethofumesate at 3 pt/A plus Dual Magnum at 1 pt/A followed by UpBeet at 1 oz/A to cotyledon to 2-leaf sugarbeet also caused visual injury expressed as chlorosis and injury was greater than ethofumesate plus Dual Magnum alone.

An experiment was conducted near Prosper, ND to determine if the loss in ground cover in plots treated with soil-applied herbicide could be overcome by increasing the cover crop seeding rate (data not presented). The answer was generally ‘no’. That is, seeding a grass species at a greater density generally meant more grass was killed by the soil-applied herbicide. Thus, we were not able to overcome the detrimental effects of soil-applied herbicide on cover crop establishment by increasing the cover crop seeding rate.

Table 4. Sugarbeet injury as percent growth reduction at Crookston and Herman 27 and 24 days after planting, respectfully.

Treatment[1]	Rate	Foxhome	Crookston	Herman	Lake Lillian
	pt or oz/A	----------% sugarbeet injury----------			
Untreated		-[4]	0	0	-
Dual Magnum	0.5	-	0	0	-
Dual Magnum	1	-	3	0	-
Ethofumesate	2	-	4	0	-
Ethofumesate	3	-	9	0	-
Dual + Etho	0.5+2	-	9	0	-
Dual + Etho	1+2	-	9	0	-
Dual + Etho	0.5+3	-	6	5	-
Dual + Etho	1+3	-	16	5	-
Dual + Etho / UpBeet[2]	1+3 / 1oz	-	29	3	-
LSD (0.05)		**-**	**8**	**NS**	**-**

[1]Roundup PowerMax at 28 fl oz/A plus Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v was applied at the sugarbeet 4- to 6-leaf stage and was repeated on approximately 14 day intervals at 28 fl oz/A and 22 fl oz/A for weed control in all treatments including the untreated.
[2]Upbeet at 1 oz/A plus methylated seed oil at 1.5% v/v was applied when sugarbeet were cotyledon to 2-leaf.
[3]DAP=days after planting
[4]- = evaluation not taken

Future Research

There were several questions that arose from these experiments. First, why did spring seeded cereals respond differently to Dual Magnum and ethofumesate? Was the difference related to the herbicide, herbicide rate, or did timing of activating rainfall contribute to cover crop stand reduction? Second, we currently believe the best way to control waterhemp in sugarbeet is preemergence. Thus we need to understand the interaction between soil-applied herbicides and cover crops. However, Dual Magnum, Outlook, and Warrant applied lay-by might be safer to cover crop species than a preemergence application of Dual Magnum or ethofumesate. Finally, these experiments were not designed to measure weed suppression by cover crops. This parameter will be incorporated into future experiments.

CONTROLLING VOLUNTEER ROUNDUP READY® CORN IN ROUNDUP READY® SUGARBEET AT CROOKSTON, MINNESOTA IN 2014

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The objective of this study was to determine the lowest herbicide rates needed to effectively control volunteer Roundup Ready (RR) corn in RR sugarbeet.

MATERIALS AND METHODS

'DeKalb 39-07 VT Double Pro' corn was seeded 2 inches deep in 44 inch rows at 9,500 seeds per acre perpendicular to plots on May 21, 2014. 'SES 36272 RR' sugarbeet was seeded 1 inch deep in 22 inch rows at 60,825 seeds per acre on May 21. 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 insecticide at 8.9 pounds product per acre was applied in a 5-inch band and drag chain incorporated at planting. Herbicide treatments were applied June 18 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 30 feet in length. Ammonium sulfate from Winfield Solutions as N-Pak AMS at 2.5% v/v was used in all treatments.

Sugarbeet injury and corn control was evaluated June 27 and July 7. 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

Date	June 18
Time of Day	11:00 AM
Air Temperature (F)	71
Relative Humidity (%)	61
Wind Velocity (mph)	15
Wind Direction	NE
Soil Temp. (F at 6")	64
Soil Moisture	Good
Cloud Cover	75
Sugarbeet stage (avg)	4 lf
Corn stage (avg)	V4-V5 / 7" tall

SUMMARY

Sugarbeet injury was not significant from any treatment. Rainfall following planting was greater than normal and sugarbeet visual injury was most likely due to variability caused by standing water rather than herbicide. Assure II (quizalofop) and Select Max (clethodim) are Group 1 ACCase Inhibiting herbicides and are safe for use in virtually all broadleaf crops grown in North Dakota and Minnesota.

Herbicide application was made when corn was V4 to V5 and about 7 inches tall. Corn that is taller or more mature may require greater herbicide rates for acceptable levels of control than those which effectively controlled corn in this trial. Corn control evaluated July 7 was 100% from Assure II at 1, 2, or 4, fl oz/A and Select Max at 6 fl oz/A (Table 2). Corn control evaluated June 27 was greatest from Assure II at 2 or 4 fl oz/A and Select Max at 6 fl oz/A. This suggests Assure II at 1 fl oz/A may not provide as rapid of control in volunteer corn as 2 or 4 fl oz/A. However, for all herbicides and rates evaluated, corn control increased from 9 days after treatment (dat), or June 27, to 19 dat, or July 7, indicating that maximum levels of control of grassy weeds from ACCase herbicides should not be expected until 14 to 21 dat. Assure II + Select Max at 1+1 fl oz/A or 2+2 fl oz/A gave similar control on June 27 and 100% control on July 7. The most economical treatment that provided 100% corn control at 19 dat was Select Max

at 6 fl oz/A which cost $16.10 per acre. This is primarily due to the cost of adjuvants used with Assure II. Destiny HC is a high surfactant methylated seed oil concentrate (HSMOC) and was chosen for use with Assure II for its ability to enhance Assure II activity while maintaining efficacy of PowerMax (glyphosate). Methylated seed oils (MSOs) may reduce glyphosate efficacy and were, therefore, not chosen for use in this trial.

Table 2. Sugarbeet injury and Roundup Ready corn control in Roundup Ready Sugarbeet at Crookston, MN in 2014.

			Sugarbeet Injury		Corn Control	
Treatment	Rate	Cost[4]	June 27	July 7	June 27	July 7
	fl oz/A	$/A	----------%----------			
PowerMax[1]	28	10.47	0	0	0	0
PowerMax+Assure II[2]	28+1	17.21	0	4	82	100
PowerMax+Assure II	28+2	18.19	0	3	88	100
PowerMax+Assure II	28+4	20.14	0	3	96	100
PowerMax+Select Max[1]	28+1	11.41	1	0	70	78
PowerMax+Select Max	28+2	12.35	1	0	65	91
PowerMax+Select Max	28+4	14.22	2	0	70	96
PowerMax+Select Max	28+6	16.10	3	9	90	100
PowerMax+Assure II+Select Max[3]	28+1+1	19.51	1	0	89	100
PowerMax+Assure II+Select Max	28+2+2	21.43	3	0	97	100
LSD (0.05)			NS	NS	8.2	3.9

[1]Applied with Prefer 90 NIS at 0.25 %v/v + N-Pak AMS at 2.5 % v/v
[2]Applied with Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5 % v/v
[3]Applied with Destiny HC at 1.5 pt/A + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v
[4]Cost per acre as calculated from the 2015 North Dakota Weed Control Guide, pages 118-125.

CONTROLLING VOLUNTEER ROUNDUP READY® SOYBEAN IN ROUNDUP READY® SUGARBEET AT CROOKSTON, MINNESOTA IN 2014

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The objective of this study was to determine the lowest herbicide rates needed to effectively control volunteer Roundup Ready (RR) soybean in RR sugarbeet.

MATERIALS AND METHODS

'Asgrow A1026505' Roundup Ready 2 Yield soybean was seeded 1 inch deep in 44 inch rows at 34,450 seeds per acre perpendicular to plots on May 21, 2014. 'SES 36272 RR' sugarbeet was seeded 1 inch deep in 22 inch rows at 60,825 seeds per acre on May 21. 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 insecticide at 8.9 pounds product per acre was applied in a 5-inch band and drag chain incorporated at planting. Herbicide treatments were applied June 18 and 30 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 30 feet in length. Ammonium sulfate from Winfield Solutions as N-Pak AMS at 2.5% v/v was used in all treatments.

Sugarbeet injury and soybean control was evaluated June 27 and July 7. 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

Application Code	A	B
Date	June 18	June 30
Time of Day	11:30 AM	10:30 AM
Air Temperature (F)	71	68
Relative Humidity (%)	61	57
Wind Velocity (mph)	15	15
Wind Direction	NE	W
Soil Temp. (F at 6")	64	65
Soil Moisture	Good	Good
Cloud Cover	75	10
Sugarbeet stage (avg)	4 lf	7 lf
Soybean stage (avg)	V1 to V2 - 4" tall	V2 to V5 – 6" tall

SUMMARY

Sugarbeet injury was not significant from any treatment. Rainfall following planting was greater than normal and any sugarbeet visual injury was most likely due to variability caused by standing water rather than herbicide. Sugarbeet injury from Stinger is often times observed as leaf curling.

Soybean control evaluated July 7 was greatest from Stinger at 2 or 3 fl oz/A or sequential applications of 2 fl oz/A and ranged from 92% to 97%. One fluid ounce of Stinger applied either once or twice gave less soybean control than one application of Stinger at 3 fl oz/A or two applications of Stinger at 2 fl oz/A. A single application of Stinger at 2 to 3 fl oz/A when volunteer soybean are about 4 inches tall should provide acceptable soybean control in Roundup Ready sugarbeet.

Table 2. Sugarbeet injury and Roundup Ready soybean control in Roundup Ready sugarbeet at Crookston, MN in 2014.

Treatment[1]	Rate	Application Code[2]	Cost[3]	Sugarbeet Injury		Corn Control	
				June 27	July 7	June 27	July 7
	fl oz/A		$/A	----------%----------			
PowerMax	28	A B	20.95	0	0	0	0
PowerMax+Stinger fb PMax	28+1 fb 28	A fb B	24.70	1	0	69	78
PowerMax+Stinger fb PMax	28+2 fb 28	A fb B	28.45	1	5	75	92
PowerMax+Stinger fb PMax	28+3 fb 28	A fb B	32.20	1	1	83	97
PowerMax+Stinger	28+1	A B	28.45	0	1	75	85
PowerMax+Stinger	28+2	A B	35.95	2	2	81	93
LSD (0.05)				NS	NS	9.0	7.9

[1]All treatments applied with Prefer 90 NIS at 0.25 %v/v + N-Pak AMS at 2.5 % v/v
[2]Application code refers to information in Table 1
[3]Cost per acre as calculated from the 2015 North Dakota Weed Control Guide, pages 118-125.

WEEDS MANAGEMENT IN A CROP SEQUENCE CONTRIBUTES TO A FIELD-BASED WEED CONTROL STRATEGY IN SUGARBEET

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Summary

1. Preemergence, preemergence followed by postemergence, and postemergence herbicide applications provided very good to excellent control of waterhemp and other grass and broadleaf weeds in corn and soybean.
2. There are more options for control of waterhemp and grass and broadleaf weeds in corn than soybean.
3. Research needs to be expanded to include weed control in cereals since small grains are an important component of the crop sequence in sugarbeet fields.
4. Have a goal of zero tolerance for weed escapes in fields in the sequence to be planted to sugarbeet.

Introduction

Utilization of the Roundup Ready (RR) sugarbeet weed control system revolutionized the control of weeds following its introduction in 2008. While weeds were not regarded as a serious production problem by sugarbeet growers who completed the 2014 annual sugarbeet growers' survey, the percent of growers reporting excellent weed control using glyphosate has trended downward since 2008 and the number of growers reporting good weed control has trended higher. Weed shifts, as a result of selecting for biotypes of weeds with greater glyphosate tolerance, is a natural process but probably has been accelerated by the use of the RR weed control system in multiple crops in the crop sequence and may partially explain results from the sugarbeet growers' survey. Changes in weed communities resulting from biotypes that do not respond the same to glyphosate are occurring and will continue to occur in eastern North Dakota and Minnesota.

Weeds that can be hard to control with glyphosate occur in most sugarbeet producing regions of the Red River Valley and southern Minnesota (Figure 1). Hard-to-control weeds are weeds by which selection pressure from repeated use of glyphosate without interruption by herbicides with other modes of action or other weed management practices has occurred. Hard-to-control weeds in sugarbeet include waterhemp, kochia, common ragweed, and giant ragweed. We know that full glyphosate rates do not always provide complete control of hard-to-control weeds in sugarbeet. We also know that there are only a limited number of tank-mix options for their control in sugarbeet. A concept we have begun to explore is a weeds management strategy where herbicides from multiple herbicide families are used in crops grown in rotation with sugarbeet to indirectly benefit weed control in sugarbeet. Preliminary experiments were conducted in 2014 to investigate the feasibility and experimental design needed for conducting this research with the idea of expanding the approach and assigning the program to a graduate student in 2015.

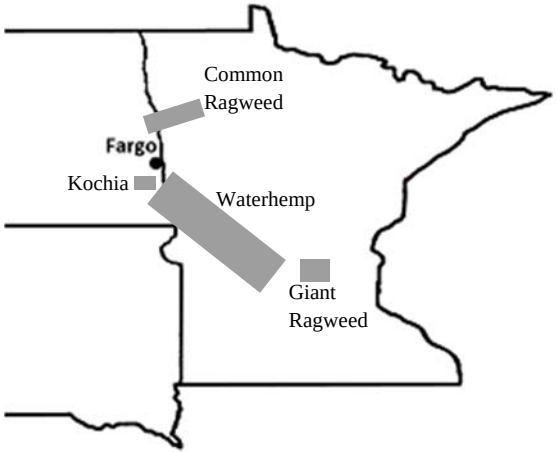
The objectives in 2014 were to provide waterhemp (Amaranthus spp.) and kochia (kochia scoparia) control in corn and soybean utilizing a 'systems approach' that:

1. is not reliant upon Roundup Ready technology
2. provides greater than 90% visual control of waterhemp and kochia season-long
3. utilizes herbicides from herbicide families grouped by mode of action that compliment herbicides used in other crops within the cropping sequence including sugarbeet
4. utilizes herbicides with appropriate rotation restrictions thereby allowing corn, soybean, and sugarbeet to be planted in the crop sequence
5. considers weed control costs per acre including cost of the seed (profitability)

Materials and Methods

Experiments were conducted on natural populations of waterhemp near Herman, MN and on natural populations of kochia and lambsquarters near Barney, ND in 2014. 'DKC 37-38 RIB' RR corn and Peterson Farm Seed

Figure 1. Geographies where various weeds interfere with sugarbeet production in eastern North Dakota and Minnesota.



'L05-11NLL' Liberty Link soybean was seeded in 22 inch rows on May 30 in separate trials at Herman and on May 28 in separate trials at Barney. Herbicide treatments were applied May 30, June 23, and July 2 at Herman and May 28, June 24, and July 2 at Barney. Environmental data at application is recorded in Table 1 for Herman trials and Table 2 for Barney trials.

Table 1. Application information for corn and soybean trials near Herman, MN in 2014.

Application code	A	B	C
Date	May 30	June 23	July 2
Time of Day	1:30 PM	3:00 PM	1:00 PM
Air Temperature (F)	93	78	70
Relative Humidity (%)	35	48	35
Wind Velocity (mph)	7	8	6
Wind Direction	S	W	WNW
Soil Temp. (F at 6")	68	72	65
Soil Moisture	Good	Slightly Wet	Good
Cloud Cover (%)	50	50	5
Corn stage (avg)	PRE	V4 to V5	V7
Soybean stage (avg)	PRE	V1 to V2	V3
Waterhemp (untreated avg)	-	2.5"	5"

Table 2. Application information for corn and soybean trials near Barney, ND in 2014.

Application code	A	B	C
Date	May 28	June 24	July 2
Time of Day	5:30 PM	3:00 PM	4:15 PM
Air Temperature (F)	89	69	70
Relative Humidity (%)	31	61	49
Wind Velocity (mph)	7	4	8
Wind Direction	SE	NW	NW
Soil Temp. (F at 6")	79	65	65
Soil Moisture	Good	Good	Good
Cloud Cover (%)	20	95	40
Corn stage (avg)	PRE	V5	V7
Soybean stage (avg)	PRE	V2 to V3	V3 to V4
Lambsquarters (untreated avg)	-	3"	7"
Redroot pigweed (untreated avg)	-	3"	7"
Kochia (untreated avg)	-	2.5"	6"

All 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 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. At Herman, corn or soybean injury were evaluated on June 23, July 2, 10, and 17, and August 27 while weed control was evaluated June 23, July 2, August 27, and September 19. At Barney, corn or soybean injury were evaluated June 25 and July 11, while weed control was evaluated June 25, July 11, and August 22. Soybean yield was taken at Barney October 6 by harvesting the middle two rows by 30-feet long with a Hege combine. All evaluations at both locations 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 at both locations. Data were analyzed with the ANOVA procedure of ARM, version 9.2014.2 software package.

Results and Discussion

Herbicide treatments were identified during consultation with Dr. Richard Zollinger, NDSU Extension Weeds Specialist. Criteria to include a herbicide into the trial included: a) efficacious to waterhemp and kochia, b) were from herbicide families that would complement RR weed system used in sugarbeet and c) would not carry over to other crops planted in the sequence including a next cropping season rotation to sugarbeet.

Weed Control in Corn

Corn injury was evaluated visually at multiple growth stages at Herman and Barney. In general, herbicide treatments containing Status tended to cause more injury than other herbicide treatments, especially at the Barney location (data not presented). Corn injury was negligible from all herbicide treatments by the time corn had reached tasseling.

Grass and small-seed broadleaf weed control was evaluated at multiple time points during the season. Green foxtail pressure at Herman was light but waterhemp pressure at Herman and redroot pigweed and lambsquarters pressure at Barney were moderate to heavy. There were insufficient kochia to evaluate at Barney.

Many herbicide treatments provided between 90 and 100 percent control of green foxtail, waterhemp, lambsquarters and redroot pigweed at canopy closure in corn (Table 3). Herbicide treatments were applied preemergence (PRE), PRE followed by postemergence (POST), or POST in corn. There were several PRE herbicide treatments that contained a chloroacetamide herbicide (Harness or Verdict) for control of grasses in addition to small-seeded broadleaves in corn. Another PRE herbicide, Sharpen, also is efficacious on small seeded broadleaves but has very little grass activity.

Herbicide treatments applied POST and containing atrazine, Laudis, or Status provided broad-spectrum weed control at both locations. Widematch was selected specifically for kochia control. However, the Barney site, while having a very heavy infestation of kochia in 2013, had a very light kochia infestation and a heavy lambsquarters and redroot pigweed infestation in 2014. This emphasizes the importance of scouting and identifying weeds in fields and matching the observed weeds with the appropriate herbicide, especially in the case of POST herbicides.

Herbicide treatments that provide broad-spectrum and season-long control in corn ensure no new seeds will be deposited into the seed bank. Waterhemp and redroot pigweed seed remains viable in the soil for at least five years and lambsquarters for more than 15 years. Setting a goal of zero tolerance for weed escapes in corn and soybean benefits sugarbeet production where herbicide choices are limited and broad-spectrum weed control more difficult.

In addition to efficacy, herbicide treatments were selected based on herbicide site of action and chemical family, crop rotation restrictions, and cost (Table 4). Herbicides were selected from herbicide families including long chain fatty acid inhibitors (15), PPO inhibitors (14), photosystem II inhibitors (5), auxin inhibitors (19) and growth regulators (4). The purpose of including herbicides from a wide range of herbicide families is to complement herbicide families used in other crops in the sequence to reduce selection pressure and weed specie shifts. Also considered was the likelihood of weed resistance occurring to a herbicide family. For example, there has not been any documented incidence of weed resistance occurring with chloroacetamide herbicides. Thus, using them in multiple crops in the crop sequence is a low risk.

Table 3. Visual evaluation of weed control in corn at Herman, MN and Barney, ND in 2014.

Treatment[1]	Application Code[2]	Rate per A	----Herman---- wahe[3] Sept 19	grfx July 14	----Barney---- colq July 11	rrpw July 11
			----------%----------			
Harness+Sharpen	A	2 pt+3 fl oz	98	100	94	100
Harness+Clarity / Laudis+atrazine	A / B	2 pt +1 pt / 3 fl oz+12 fl oz	100	100	-[4]	-
Harness+Clarity / Widematch	A / B	2 pt+1 pt / 1.3 pt	-	-	95	99
Harness+atrazine / Status	A / B	2 pt+12 fl oz / 7.5 oz	100	100	100	100
Harness / Widematch	A / B	2 pt / 1.3 pt	-	-	90	99
Harness / Status	A / B	2 pt / 10 oz	100	100	100	100
Harness / Laudis+atrazine	A / B	2 pt / 3 fl oz+12 fl oz	100	100	-	-
Sharpen / Status	A / B	3 fl oz / 7.5 oz	96	95	100	100
Sharpen / Laudis+atrazine	A / B	3 fl oz / 3 fl oz+12 fl oz	99	100	-	-
Sharpen / Status+Warrant+PowerMax	A / B	3 fl oz / 5 oz+4 pt+32 fl oz	100	100	100	100
Sharpen / Widematch	A / B	3 fl oz / 1.3 pt	-	-	80	85
Verdict / Laudis + atrazine	A / B	15 fl oz / 3 fl oz+12 fl oz	100	100	-	-
Verdict / Widematch	A / B	15 fl oz / 1.3 pt	-	-	96	90
Verdict / Status	A / B	15 oz / 7.5 oz	100	99	100	100
Laudis+atrazine	B	3 fl oz+12 fl oz	99	100	100	100
Status+PowerMax	B	10 oz+32 fl oz	100	100	99	100
Widematch+Status+PowerMax / Widematch+Status+PowerMax	B / C	1 pt+5 oz+32 fl oz / 1 pt+5 oz+32 fl oz	-	-	100	100
Laudis+atrazine / Status+PowerMax	B / C	3 fl oz+12 fl oz / 5 oz+32 fl oz	100	100	-	-
PowerMax / PowerMax	B / C	32 fl oz / 32 fl oz	81	100	98	100
LSD (0.05)			**3**	**2**	**7**	**7**

[1]Clarity, Laudis, atrazine (4L), and Status applied with methylated seed oil from Loveland (MSO) at 1.5 pt/A plus N-Pak AMS at 2.5% v/v. Roundup PowerMax applied with Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v, alone, or Roundup PowerMax plus co-herbicide applied with high surfactant methylated oil concentrate (HSMOC) at 1 pt/A plus AMS at 2.5% v/v.
[2]Application code refers to information in Tables 1 and 2.
[3]wahe=waterhemp; grfx=green foxtail; colq=common lambsquarters; rrpw=redroot pigweed.
[4]No evaluation as the treatment was not present in that trial and, therefore, is not included in analysis.

The cost per acre for herbicide treatments ranged from $13 to $65 per acre. Cost of weed control is clearly an important consideration and must be included in a weeds management strategy. However, careful consideration should be taken in weighing short term benefits from cheaper weed control programs with long term weed control ramifications that may occur as a result of those cheaper programs.

Herbicides with residues that would not extend to rotational crops, including soybean or sugarbeet, were selected for the trials. Sugarbeet can be planted in the next cropping season following the herbicide treatments used in this experiment. Atrazine residues (12 months) potentially can extend from the corn crop to the soybean crop depending on rainfall conditions, time of application, and atrazine rate.

Table 4. Herbicide family, crop rotation restriction and cost per acre of corn herbicide treatments

Herbicide	Application Timing	Rate per A	Cost[2] $/A	SoA[3] Families	Crop Rotation[1] Sugarbeet	Crop Rotation[1] Soybean
Harness+Sharpen	PRE	2 pt+3 fl oz	$44	15+14	NCS	NCS
Harness+Clarity / Laudis+atrazine	PRE / POST	2 pt +1 pt / 3 fl oz+12 fl oz	$54	15+4 / 27+5	10	12
Harness+Clarity / Widematch	PRE / POST	2 pt+1 pt / 1.3 pt	$47	15+4 / 4,4	NCS	10.5
Harness+atrazine / Status	PRE / POST	2 pt+12 fl oz / 7.5 oz	$56	15+5 / 4,19	NCS	12
Harness / Widematch	PRE / POST	2 pt / 1.3 pt	$39	15 / 4,4	NCS	NCS
Harness / Status	PRE / POST	2 pt / 10 oz	$63	15 / 4,19	NCS	NCS
Harness / Laudis+atrazine	PRE / POST	2 pt / 3 fl oz+12 fl oz	$46	15 / 27+5	10	12
Sharpen / Status	PRE / POST	3 fl oz / 7.5 oz	$43	14 / 4,19	6	4
Sharpen / Laudis+atrazine	PRE / POST	3 fl oz / 3 fl oz+12 fl oz	$35	14 / 27+5	10	12
Sharpen / Status+Warrant+PowerMax	PRE / POST	3 fl oz / 5 oz+4 pt+32 fl oz	$54	14 / 4,19+15+9	NCS	NCS
Sharpen / Widematch	PRE / POST	3 fl oz / 1.3 pt	$28	14 / 4,4	6	10.5
Verdict / Laudis + atrazine	PRE / POST	15 fl oz / 3 fl oz+12 fl oz	$46	14,15 / 27+5	10	12
Verdict / Widematch	PRE / POST	15 fl oz / 1.3 pt	$39	14,15 / 4,4	NCS	10.5
Verdict / Status	PRE / POST	15 oz / 7.5 oz	$54	14,15 / 4,19	NCS	4
Laudis+atrazine	POST	3 fl oz + 12 fl oz	$19	27+5	10	12
Status+PowerMax	POST	10 oz+32 fl oz	$41	4,19+9	4	4
Widematch+Status+PMax / Widematch+Status+PMax	POST / POST	1 pt+5 oz+32 fl oz / 1 pt+5 oz+32 fl oz	$65	4,4+4,19+9/ 4,4+4,19+9	4	10.5
Laudis+atrazine / Status+PowerMax	POST / POST	3 fl oz+12 fl oz / 5 oz+32 fl oz	$43	27+5 / 4,19+9	10	12
PowerMax / PowerMax	POST / POST	32 fl oz / 32 fl oz	$13	9 / 9	0	0

[1]Crop rotation restrictions for North Dakota. 2015 North Dakota Weed Control Guide, pages 102-107. Table values = number of months. NCS = next crop season after herbicide application.

[2]Cost per acre as calculated from the 2015 North Dakota Weed Control Guide, pages 118-125. Cost does not include recommended adjuvants

[3]Herbicide Site of Action and Chemical Family for Resistant Weed Management. 2015 North Dakota Weed Control Guide, pages 98-99.

Weed Control in Soybean

Visual assessment of soybean growth reduction and weed control in soybean were evaluated at various times during the growing season. Soybean growth reduction was averaged over locations since soybean responded the same to herbicide treatments at both locations. Soybean injury generally was negligible from the preemergence herbicide treatments followed by Liberty, Basagran or Ultra Blazer (Table 5). However, Cadet alone, Cadet plus Basagran and Cadet following Valor gave soybean injury ranging from 17 to 29%, in mid-July when soybean growth stage ranged from V5 to V7. Cobra also caused soybean stature reduction injury. Growers apply Cadet and Cobra before flowering and report no yield effects. Soybean was harvested at the Barney location and yield data (not presented) tends to support grower feedback. In general, the yield impact from insufficient weed control tended to mask any effect from phytotoxic effects of herbicide.

Herbicide treatments provided broad-spectrum waterhemp, lambsquarters and redroot pigweed control (Table 5). Control generally was best from soil-applied herbicides following POST herbicide treatments. The POST only treatments tended to be less consistent and did not provide broad-spectrum control. As with corn, scouting fields, proper identification of weeds and an understanding of weed biology is very helpful to ensure excellent weed control. Waterhemp control was less than redroot pigweed control and tended to be less than lambsquarters control. We attribute these differences to differences in herbicide efficacy (for example, Cobra is weak on lambsquarters) but also differential emergence of waterhemp which likely emerged later than redroot pigweed and lambsquarters and subsequent to herbicide applications.

Soybean herbicide treatments were selected based on herbicide site of action and chemical family, crop rotation restrictions, and cost (Table 6). Herbicide were selected from herbicide families including long chain fatty acid

inhibitors (15), PPO inhibitors (14), photosystem II inhibitors (6), and glutamine synthetase inhibitors (10). Note that a number of PRE and POST herbicide treatments were PPO inhibitors (14). There are not as many herbicide choices in soybean as corn that allow crop rotation to sugarbeet the following season. However, the soybean herbicides used in these trials generally have no rotational impact on crops grown in the rotation including corn or sugarbeet.

Table 5. Visual soybean injury and weed control in soybean at Herman, MN and Barney, ND, 2014.

			2 locations	Herman	------Barney------	
Treatment[1]	**Application Code[2]**	**Rate per A**	**Soybean Injury Jul 14**	**wahe[3]cntl Sept 19**	**colq cntl Aug 22**	**rrpw cntl Aug 22**
			----------%----------			
Dual Magnum+Valor / Liberty	A / B	2 pt+3 oz / 29 fl oz	4	96	98	100
Sharpen+Valor / Liberty	A / B	1 fl oz+3 oz / 29 fl oz	0	95	100	98
Verdict+Valor / Liberty	A / B	5 fl oz+3 oz / 29 fl oz	3	93	94	100
Outlook+Verdict+Valor / Liberty	A / B	14 fl oz+5 fl oz+3 oz / 29 fl oz	6	95	100	100
Valor / Cadet / Cadet	A / B / C	3 oz / 0.7 fl oz / 0.7 fl oz	19	77	93	99
Valor / Ultra Blazer / Ultra Blazer	A / B / C	3 oz / 1 pt / 1 pt	6	99	98	100
Valor / Basagran / Basagran	A / B / C	3 oz / 1 pt / 1 pt	4	69	100	100
Verdict / Basagran / Basagran	A / B / C	5 fl oz / 1 pt / 1pt	0	84	76	95
Sharpen + Warrant / Basagran / Basagran	A / B / C	1 fl oz+3 pt / 1 pt / 1 pt	3	81	89	100
Basagran / Basagran	B / C	1 pt / 1 pt	2	0[4]	75	88
Cadet / Cadet	B / C	0.7 fl oz / 0.7 fl oz	17	61	75	86
Cobra / Cobra	B / C	10 fl oz / 10 fl oz	37	69	15	100
Basagran + Cadet / Basagran + Cadet	B / C	0.5 pt+0.7 fl oz / 0.5 pt+0.7 fl oz	29	61	63	86
Liberty / Liberty	B / C	29 fl oz / 29 fl oz	2	95	97	100
LSD (0.05)				**13**	**13**	**8**

[1]Liberty applied with N-Pak AMS at 3 lb/A; Cadet, Basagran, and Cobra applied with MSO at 1.5 pt/A, Ultra Blazer applied with Prefer 90 NIS at 1.5 pt/100 gal.
[2]Application codes refer to information in Tables 1 and 2.
[3]wahe=waterhemp; cntl=control; colq=common lambsquarters; rrpw=redroot pigweed
[4]a misapplication may have occurred

Cost of weed control in soybean ranged from $16 to $69 per acre. In general, herbicides treatments that included a PRE herbicide component were more expense than POST only herbicide treatments. Growers should use due caution when making a short-term financial decision that may have long-term implications. Also, while PPO inhibitor herbicides (14) may be less expense than chloroacetamide herbicides (15), PPO inhibitors have a higher incidence of weed resistance.

Conclusions

A weed control option for control of tough weeds in sugarbeet is weed control throughout the crop sequence. Adapting and using this approach requires development of a strategy for cropping sequence, selecting a diverse array of herbicide treatments and herbicide families, maintaining good record keeping, and a commitment to prevent weed seed from entering the soil seedbank during the 'non-sugarbeet' crops. It is important that growers learn about the biology of weeds including temperature, moisture, and tillage patterns that impact the ability of weed seed to break dormancy and their longevity in the soil seedbank.

Table 6. Herbicide family, crop rotation restriction and cost per acre of corn herbicide treatments

Treatment	Application	Rate per A	Cost[2] $/A	SoA[3] Families	Crop Rotation[1] Sugarbeet	Crop Rotation[1] Corn
Dual Magnum+Valor / Liberty	PRE / POST	2 pt+3 oz / 29 fl oz	$69	15+14 / 10	5	1
Sharpen+Valor / Liberty	PRE / POST	1 fl oz+3 oz / 29 fl oz	$44	14+14 / 10	4	1
Verdict+Valor / Liberty	PRE / POST	5 fl oz+3 oz / 29 fl oz	$47	14,15+14 /10	NCS	1
Outlook+Verdict+Valor/ Liberty	PRE / POST	14 fl oz+5 fl oz+3 oz / 29 fl oz	$68	15+14,15+14/ 10	NCS	1
Valor / Cadet / Cadet	PRE/POST/POST	3 oz / 0.7 fl oz / 0.7 fl oz	$36	14 / 14 / 14	5	1
Valor / Ultra Blazer / Ultra Blazer	PRE / POST / POST	3 oz / 1 pt / 1 pt	$42	14 / 14 / 14	5	1
Valor / Basagran / Basagran	PRE / POST / POST	3 oz / 1 pt / 1 pt	$46	14 / 6 / 6	5	1
Verdict / Basagran / Basagran	PRE / POST / POST	5 fl oz / 1 pt / 1pt	$35	14,15 / 6 / 6	NCS	1
Sharpen + Warrant / Basagran / Basagran	PRE / POST / POST	1 fl oz+3 pt / 1 pt / 1 pt	$47	14+15 / 6 / 6	NCS	NCS
Basagran / Basagran	POST / POST	1 pt / 1 pt	$26	6 / 6	0	0
Cadet / Cadet	POST / POST	0.7 fl oz / 0.7 fl oz	$16	14 / 14	0	0
Cobra / Cobra	POST / POST	10 fl oz / 10 fl oz	$31	14 / 14	0	0
Basagran + Cadet / Basagran + Cadet	POST / POST	0.5 pt+0.7 fl oz / 0.5 pt+0.7 fl oz	$29	6+14 / 6+14	0	0
Liberty / Liberty	POST / POST	29 fl oz / 29 fl oz	$39	10 / 10	0	0

[1]Crop rotation restrictions for North Dakota. 2015 North Dakota Weed Control Guide, pages 102-107. Table values = number of months. NSC = next crop season after herbicide application.
[2]Cost per acre as calculated from the 2015 North Dakota Weed Control Guide, pages 118-125. Cost does not include recommended adjuvants
[3]Herbicide Site of Action and Chemical Family for Resistant Weed Management. 2015 North Dakota Weed Control Guide, pages 98-99

Sugarbeet growers should carefully consider the number of crops where glyphosate is the primary herbicide for weed control. Glyphosate will be used in sugarbeet. The goal is for growers to compliment glyphosate use in sugarbeet with other herbicides from other families in crops grown in the field in sequence with sugarbeet by using the decision support tools discussed in this paper.

Finally, making weed control decisions can be very complex and is an exercise that requires data from multiple sources. Over time it may be valuable to adapt the decision support systems that growers use in choosing weed control solutions from crop-based to weeds-based and in a format that is readily available to the decision-maker.