A STRATEGY FOR MANAGING WATERHEMP IN SUGARBEET

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Summary

1. Making multiple applications of glyphosate in a single season is not a stand-alone strategy for waterhemp control in sugarbeet.
2. UpBeet, Betamix, or UpBeet plus Betamix applied with glyphosate plus ethofumesate improves waterhemp control compared to glyphosate plus ethofumesate, but does not provide season-long waterhemp control.
3. Soil-applied herbicides applied pre-plant incorporated (PPI) or preemergence (PRE) are effective at controlling waterhemp but may not provide season-long control.
4. Soil-applied herbicides applied postemergence to sugarbeet (lay-by) has provided the most efficacious and consistent waterhemp control across locations and years.

Introduction

Waterhemp continues to be a tough weed to control in fields planted to sugarbeet in Minnesota and eastern North Dakota. Fields with waterhemp as a problem are growing in number as waterhemp seeds are moving, presumably being carried in water, by Canada geese, and by humans who transport farm and service equipment. In 2014, waterhemp was found in sugarbeet fields in southern Cass and Clay Counties in North Dakota and Minnesota. Waterhemp was identified 130 miles north in 2015 or in Walsh County, North Dakota and Polk County, Minnesota.

Waterhemp is a summer annual weed in the pigweed family that can germinate in late May, June, and July in North Dakota and Minnesota which is much later than redroot pigweed or smooth pigweed. Waterhemp germinates and emerges from the soil surface to one-half inch deep in the soil and remains viable in soils from four to six years. A unique feature about waterhemp is male and female flowers are located on separate plants (dioecious). That is, male plants produces pollen and female plants make seed. This unique biology creates tremendous genetic diversity in populations and results in plants that are biologically and morphologically unique. It also has contributed to development of biotypes that are resistant to several herbicide families including ALS inhibitor (2), triazine (5), PPO inhibitor (14), and glyphosate (9) in Minnesota and North Dakota.

Sugarbeet fields in most growing regions received timely precipitation in 2015 that contributed to record sugarbeet yields. The precipitation also benefited waterhemp, especially in areas of fields with an open canopy. Frequent rains and open canopies allowed for multiple flushes of waterhemp in sugarbeet, soybean, and small grain stubble in July and August. Waterhemp was regarded by 46% of farmers who completed the annual survey of weed control and production practices in sugarbeet as their worst weed problem in 2015, well ahead of common ragweed (16%) and lambsquarters (10%).

Researchers and Agriculturalist have developed significant datasets and experiences dating back to waterhemp experiments conducted in sugarbeet near Hector, MN in 2010. Experiments designed to evaluate different approaches for waterhemp control have been conducted each year since 2010. The objectives of 2015 experiments were to: a) evaluate waterhemp control from S-metolachlor, ethofumesate, or S-metolachlor + ethofumesate applied PRE followed by multiple applications of glyphosate; b) evaluate waterhemp control from S-metolachlor, Warrant, or Outlook applied lay-by in sugarbeet; and; c) evaluate waterhemp control from multiple applications of glyphosate + POST herbicide combinations in sugarbeet. The purpose of this report is to summarize research from 2014 and 2015 on waterhemp control in sugarbeet and present our best recommendations for sugarbeet growers to use in their operations.

Materials and Methods

Experiments were conducted on natural populations of waterhemp near Herman and Moorhead, Minnesota in 2015. Plot area was worked by the cooperating farmer with a John Deere field cultivator equipped with rolling baskets on June 4, 2015 at Herman and with a Kongskilde s-tine field cultivator on April 30, 2015, at Moorhead. 'SesVanderhave 36271RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on June 4 and April 30, 2015, respectively. Herbicide treatments were applied at Herman June 4, June 18, and July 7, 2015 and at Moorhead May 1, June 2, and June 19, 2015. 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 fields with moderate to heavy infestations of glyphosate-resistant waterhemp. Ammonium sulfate (AMS) in all treatments was 'N-Pak' AMS, a liquid formulation from Winfield Solutions. Non-ionic surfactant (NIS) was 'Prefer 90', a product from West Central, Inc.

Sugarbeet injury was evaluated July 7, July 21, and July 31 at Herman, MN, and June 11 and July 1, 2015 at Moorhead, MN. Waterhemp control was evaluated July 7, July 21, and July 31, 2015 at Herman, MN, and June 11, July 1, and August 25, 2015 at Moorhead, MN. Lambsquarters control was evaluated July 21, 2015 at Herman, MN and August 25, 2015 at Moorhead, MN. 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 2015.6 software package and with the ANOVA procedure as a split-plot analysis to determine interaction effects using SAS Data Management version SAS 9.3 software package.

Table 1. Application information for sugarbeet trials near Herman, MN in 2015.

Application code	A	B	C
Date	June 4	June 18	July 7
Time of Day	4:00 PM	6:00 PM	1:00 PM
Air Temperature (F)	72	71	74
Relative Humidity (%)	55	45	43
Wind Velocity (mph)	4	8	4
Wind Direction	SE	N	SE
Soil Temp. (F at 6")	63	68	66
Soil Moisture	Good	Good	Dry
Cloud Cover (%)	98	15	5
Sugarbeet stage (avg)	PRE	2 lf	8 lf

Table 2. Application information for sugarbeet trials near Moorhead, MN in 2015.

Application code	A	B	C
Date	May 1	June 2	June 19
Time of Day	12:00 PM	8:00 AM	3:00 PM
Air Temperature (F)	75	63	80
Relative Humidity (%)	28	62	45
Wind Velocity (mph)	3	7	7
Wind Direction	NW	SE	SE
Soil Temp. (F at 6")	60	58	66
Soil Moisture	Good	Wet	Good
Cloud Cover (%)	10	95	90
Sugarbeet stage (avg)	PRE	2-4 lf	4-6 lf

Results and Discussion

Sugarbeet experiments were conducted at multiple locations in 2014 and 2015 to evaluate waterhemp control. Waterhemp control ranged from 34% to 66% across experiments and years from either two or three POST applications of Roundup PowerMax (Table 3). In all experiments, Roundup PowerMax was applied with NIS and AMS. The data shown in Table 3 indicate the presence of glyphosate-resistant waterhemp biotypes that were not

controlled with multiple full-rate applications of glyphosate. These data are consistent with results from experiments conducted from 2010 through 2013 and conclude that making repeat applications of glyphosate alone is not an effective strategy to control waterhemp in sugarbeet fields.

Table 3. Waterhemp control from two or three applications of glyphosate[1] at four locations in 2014 and 2015.

	Herman, MN 2014	Herman, MN 2015	Moorhead, MN 2015	Lake Lillian, MN 2015
	----------% waterhemp control[2]----------			
Experiment 1	33	48	60	48
Experiment 2	35	56	34	-
Experiment 3	36	58	66	60
Experiment 4	-[3]	48	39	-

[1]Roundup PowerMax at 28 followed by (fb) 28 fb 22 fl oz/A or Roundup PowerMax at 28 fb 28 fl oz/A; + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v

[2]Visual percent waterhemp control at preharvest evaluation

[3]- indicates experiment was not conducted at that location

To help manage weed resistance, university scientists from the Midwest recommend combining glyphosate with 'effective' waterhemp-control herbicides that represent different sites of action (SOA) than glyphosate. In sugarbeet, glyphosate can be applied in combination with Betamix (SOA 5), ethofumesate (SOA 8) and/or UpBeet (SOA 2) for improved waterhemp control. University scientists also recommend using high surfactant methylated oil concentrate (HSMOC) adjuvants when glyphosate is tank-mixed with other herbicides and to apply herbicides to small waterhemp, no more than 2 to 4 inches tall. HSMOC adjuvants were developed to enhance oil-based herbicides without antagonizing glyphosate.

Herbicide mixtures are commonly applied in crops to increase the spectrum of weed control. Waterhemp control from Roundup PowerMax plus ethofumesate at 4 fl oz/A was consistently greater than from Roundup PowerMax alone (Table 4). Numeric improvement in waterhemp control from the addition of ethofumesate to glyphosate was modest (5% to 20%). Improvement in control from addition of ethofumesate may be related to changes in the composition of the cell wall that enable more glyphosate to penetrate. Ethofumesate has been document to increase uptake of other foliar applied herbicides, thus improving season-long control (1,2).

Waterhemp control from Roundup PowerMax + ethofumesate and/or tank-mix herbicides was dependent on location and year (Table 4). For example, waterhemp control was much greater at Moorhead in 2015 compared to Herman in 2014 or 2015 and might be an anomaly. Improved waterhemp control was attributed to three factors observed at Moorhead: 1) herbicide applications were made when waterhemp was small (one to two inches tall); 2) sugarbeet were actively growing; and 3) optimum to excessive soil moisture conditions may have resulted in damping-off of waterhemp population as there was very little further growth and development in June and July.

Tank-mixing Roundup PowerMax + ethofumesate + either Betamix or UpBeet improved numeric waterhemp control 6% to 33% compared to PowerMax +ethofumesate alone but was statistically significant at only one of four locations. However, the three-way mixtures averaged only 72% to 78% waterhemp control across locations, which is insufficient. These data across multiple experiments and multiple years conclude that waterhemp cannot be consistently and effectively controlled by relying solely upon POST herbicides.

Table 4. Waterhemp control from glyphosate alone and glyphosate in combination with broadleaf herbicides in sugarbeet, across locations in 2014 and 2015.

Treatment[1]	Rate	Herman 2014	Herman 2015	Moorhead 2015	Lake Lillian 2015	Average[4]
	(fl oz or oz/A)	----------% waterhemp control[3]----------				
PMax[2] / PMax / PMax	**28 / 28 / 22**	36	20	66	61	46
PMax+Etho / PMax+Etho / PMax+Etho	**28+4 / 28+4 / 22+4**	58	40	81	66	61
PMax+Bmix / PMax+Bmix / PMax+Bmix	**28+12 / 28+16 / 22+24**	65	40	86	68	65
PMax+UpBeet / PMax+UpBeet / PMax+UpBeet	**28+0.75 / 28+0.75 / 22+0.75**	51	48	90	69	65
PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	**28+4+12 / 28+4+16 / 22+4+24**	69	73	88	78	78
PMax+Etho+UpBeet / PMax+Etho+UpBeet / PMax+Etho+UpBeet	**28+4+0.75 / 28+4+0.75 / 22+4+0.75**	64	68	93	64	72
PMax+Bmix+UpBeet / PMax+Bmix+UpBeet / PMax+Bmax+UpBeet	**28+4+12 / 28+4+16 / 22+4+24**	64	64	96	83	76
	LSD (0.05)	**20**	**18**	**12**	**NS**	**-**

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8; / indicates a different application timing
[3]Visual percent waterhemp control at preharvest evaluation
[4]Average across locations included for visual comparison and has not been analyzed statistically

University scientists from the Midwest also recommend using soil-applied herbicides for waterhemp control. Several soil-applied herbicide options exist in sugarbeet that represent different herbicide SOAs. Eptam and Ro-Neet (SOA 5) must be incorporated immediately after application to about four inches deep. Most sugarbeet growers are not willing to incorporate four inches deep due to soil moisture content in the spring and the detrimental effects this tillage may have on the seedbed and subsequent sugarbeet emergence. Soils following incorporation are also susceptible to losses from wind erosion. Ethofumesate is a good soil-applied herbicide that can be applied PRE but costs $94 per acre broadcast compared to $25 per acre for Dual Magnum (s-metolachlor).

Ro-Neet applied PPI, ethofumesate applied PPI, and ethofumesate applied PRE provided 91, 96, and 98% waterhemp control, respectively, at Lake Lillian, MN in 2015 (Table 5.) This location is characterized with high organic matter and fine textured soils. Ro-Neet and ethofumesate historically have provided good crop safety and weed control in soils in southern Minnesota.

Research has been conducted to evaluate sugarbeet safety and weed control from S-metolachlor since 1985. The research contributed to S-metolachlor being registered in sugarbeet in 2003. However, in its first season, S-metolachlor caused sugarbeet stand loss in fields, presumably due to cold and wet conditions after herbicide applications. In an effort to improve crop safety yet still provide acceptable weed control, recent experiments have evaluated S-metolachlor at low rates (0.5 to 0.75 pt/A) in a systems approach with other sugarbeet herbicides.

S-metolachlor applied PRE at 0.5 or 0.75 pt/A followed by three applications of Roundup PowerMax at 28 / 28 / 22 fl oz/A provided 89 and 94% waterhemp control, respectively, in 2014 at Herman, MN (Table 5). Sugarbeet injury was negligible from all treatments, presumably due to the excellent growing conditions associated with warmer weather. Experiments were planted in early June in 2014 due to wet and cold conditions in late April and for much of May.

The Moorhead and Lake Lillian locations were planted in early May, 2015. The Herman location was planted in early June and had an open canopy into late July due to a significant rhizoctonia rot root infestation. S-metolachlor at 0.5 or 0.75 pt/A followed by Roundup PowerMax at 28 /28 / 22 fl oz/A did not provide season-long waterhemp control at Moorhead or Herman in 2015 (Table 5). Ethofumesate at 1 or 2 pt/A + s-metolachlor tended to improve waterhemp control compared to S-metolachlor alone, but also caused greater sugarbeet injury at Moorhead.

Many factors contribute to the longevity of chloroacetamide herbicides, such as S-metolachlor, in soils with herbicide degradation beginning immediately following application. Research suggests chloroacetamide herbicides are able to control weeds for 35 to 50 days following application (3, 4). Waterhemp does not germinate and emerge until late May and, depending on environmental conditions, will continue to germinate and emerge though July and August. Thus, in a crop such as sugarbeet that has an open canopy for the first half of the growing season, herbicides applied in mid-April or early May will not provide season-long waterhemp control.

Table 5. Sugarbeet injury and waterhemp control from soil-applied herbicide treatments, across locations in 2014 and 2015.

Treatment[1]	Rate	App. Code[3]	Herman 2014	Moorhead 2015	Herman 2014	Herman 2015	Moorhead 2015	Lake Lillian 2015
	pt/A		---% sgbt injury---		----------% waterhemp control[4]----------			
Ro-Neet SB	**5.3**	A	8	19	91	76	65	91
Ethofumesate 4SC	**6 /7[2]**	A	8	11	74	74	79	98
Ethofumesate 4SC	**6 / 7[2]**	B	3	4	70	79	86	96
S-metolachlor	**0.5**	B	6	5	89	63	61	90
S-metolachlor	**0.75**	B	9	13	94	61	74	91
S-metolachlor	**1**	B	9	18	100	69	70	92
S-metolachlor	**2**	B	10	28	99	74	85	97
Etho+S-meto[5]	**1+0.5**	B	-	11	-	71	71	96
Etho+S-meto	**2+0.5**	B	-	11	-	73	56	81
Etho+S-meto	**1+1**	B	-	20	-	76	75	97
Etho+S-meto	**2+1**	B	-	15	-	74	83	99
Etho+S-meto	**1+2**	B	-	31	-	79	89	96
Etho+S-meto	**2+2**	B	-	36	-	88	90	97
No soil Herbicide			-	14	33	48	60	48
LSD (0.05)			**8**	**10**	**9**	**12**	**10**	**11**

[1]Treatments all included Roundup PowerMax at 28 fb 28 fb 22 fl oz/A + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v
[2]Ethofumesate at 6 pt in 2014; 7 pt in 2015.
[3]Application codes are A = preplant incorporated (PPI) and B = preemergence (PRE)
[4]Visual percent waterhemp control at preharvest evaluation
[5]Etho+S-meto = Ethofumesate 4SC plus S-metolachlor

The concept of 'lay-by' is to use soil-applied herbicides after crop emergence but before weed emergence. In sugarbeet, S-metolachlor, Warrant, and Outlook can be applied POST to sugarbeet after sugarbeet have reached the two-leaf stage. Timely precipitation is required for activation since neither S-metolachlor, Warrant, nor Outlook control emerged weeds. Research conducted in 2015 suggests waterhemp emerges in Minnesota and North Dakota near the end of May. Thus, lay-by herbicide applications can be timed to waterhemp emergence rather than sugarbeet planting date. Six weeks of waterhemp control, beginning in mid-May, may extend the window for waterhemp control through June and early July or until sugarbeet canopy closure.

S-metolachlor, Warrant, and Outlook were applied lay-by at multiple locations in 2014 and 2015. Locations represented experiments with early sugarbeet planting (Moorhead, 2015) late sugarbeet planting (Herman, 2014 and Herman, 2015), and an open sugarbeet canopy (Herman, 2015). Glyphosate at 28 fl oz/A + ethofumesate at 4 fl oz/A was applied in combination with lay-by herbicides to control emerged weeds. Waterhemp control tended to be more consistent across locations and years from herbicides applied lay-by (Figure 1) compared to waterhemp control from herbicides applied PRE followed by POST (Table 5) or POST only (Table 3, Table 4). Outlook tended to provide more consistent waterhemp control than S-metolachlor or Warrant.

Waterhemp control may be related to herbicide solubility and resultant herbicide activation. Outlook is more water soluble than S-metolachlor or Warrant and thus, the more easily activated (4). Warrant is the least water soluble of the chloroacetamide herbicides and thus, most dependent on timely and significant precipitation for activation. Significant precipitation occurred four days after lay-by application and precipitation totals were 1.7 inches, two weeks after lay-by application at Moorhead, 2015. Similar precipitation totals occurred during the two week interval following lay-by application at Herman, 2015 but precipitation was more events and less total precipitation per event. Thus, activation of S-metolachlor and Warrant may not have occurred as quickly or as completely.

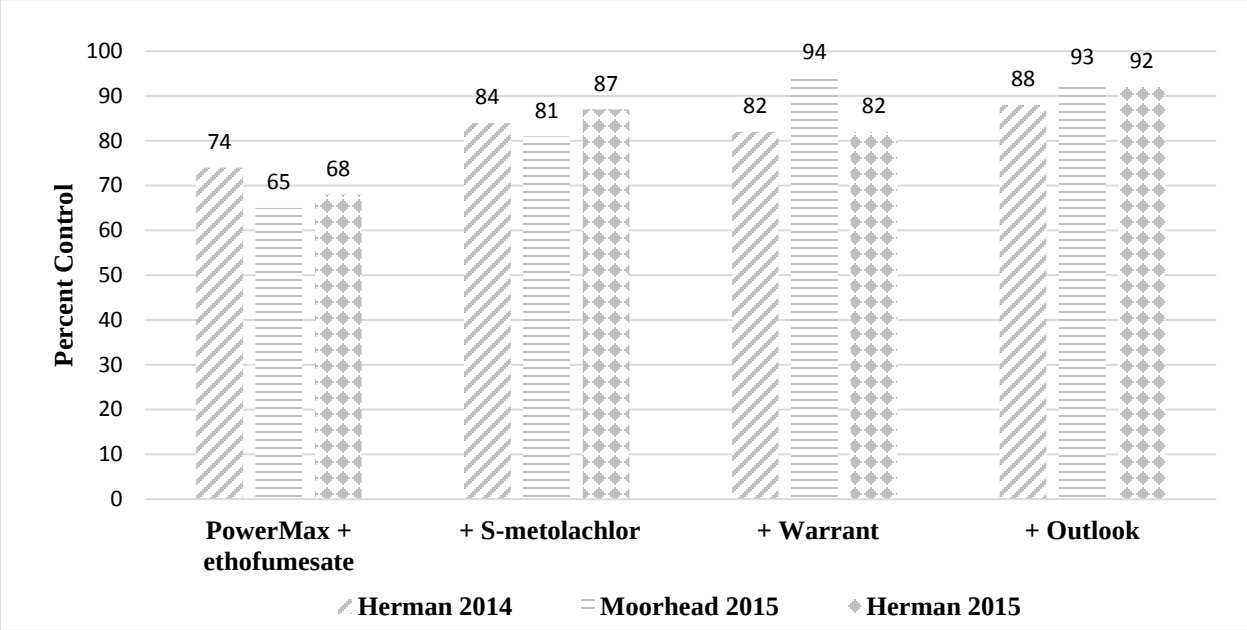

Figure 1. Waterhemp control from glyphosate plus ethofumesate and lay-by herbicides at different locations in 2014 and 2015.

There is a risk in relying on lay-by applications, that timely precipitation may not occur and thus, not activate herbicide. Preemergence herbicides followed by chloracetamide herbicides lay-by is a systems approach that may provide early-season broadleaf control including lambsquarters and redroot pigweed and available herbicide for waterhemp control until lay-by application is activated by precipitation. PRE fb lay-by may improve consistency of season-long control of waterhemp across environments.

S-metolachlor at 0.5 pt/A applied PRE followed by S-metolachlor, Outlook or Warrant provided near complete lambsquarters control and improved the consistency of waterhemp control at Herman and Moorhead in 2015 (Table 7, Table 8, Figure 2). Waterhemp control tended to be greater when S-metolachlor was applied PRE fb lay-by, compared to lay-by alone, Figure 3).

Sugarbeet stands at Herman were compromised by a severe rhizoctonia root rot infestation that compromised sugarbeet stand and confounded sugarbeet injury evaluation from herbicide treatments. Sugarbeet safety from glyphosate, lay-by or PRE fb lay-by was negligible at Moorhead.

These results are promising but are from two locations and one year's data. Further research is needed to evaluate more environments and other variations on the PRE fb lay-by concept including ethofumesate fb lay-by, splitting lay-by applications, or ethofumesate or S-metolachlor fb split lay-by.

Table 7. Sugarbeet injury, waterhemp, and lambsquarters control from lay-by herbicide treatments at Herman, MN in 2015.

Treatment[1]	Rate	App. Code[2]	Sgbt		Waterhemp			Lambquarters
			Jul 7	Jul 21	Jul 7	Jul 21	Jul 31	Jul 21
	fl oz or pt (p)/A		---% injury---		----------% control----------			
PMax[3]+Etho / PMax+Etho	**28+4 /** **28+4**	B / C	10	28	68	74	61	100
PMax+Etho+Dual / PMax+Etho	**28+4+1.25p /** **28+4**	B / C	10	21	86	93	83	100
PMax+Etho+War / PMax+Etho	**28+4+3.25p /** **28+4**	B / C	13	26	85	83	73	100
PMax+Etho+Out / PMax+Etho	**28+4+18 /** **28+4**	B / C	13	30	94	94	89	100
Dual / PMax+Etho+Dual / PMax+Etho	**0.5p / 28+4+1p /** **28+4**	A / B / C	13	30	93	89	87	100
Dual / PMax+Etho+War / PMax+Etho	**0.5p / 28+4+3p /** **28+4**	A / B / C	7	20	96	93	83	100
Dual / PMax+Etho+Out / PMax+Etho	**0.5p / 28+4+18 /** **28+4**	A / B / C	10	25	96	99	96	100
LSD (0.10)			**13**	**12**	**6**	**10**	**13**	**NS**
CV			**98**	**43**	**7**	**10**	**14**	**0**

[1]Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v
[2]Application codes refer to the information in Table 1
[3]PMax=Roundup PowerMax; Dual=Dual Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC

Table 8. Sugarbeet injury, waterhemp, and lambsquarters control from lay-by herbicide treatments at Moorhead, MN in 2015.

Treatment[1]	Rate	App. Code[2]	Sgbt		Waterhemp			Lambsquarter
			Jun 11	Jul 1	Jun 11	Jul 1	Aug 25	Aug 25
	fl oz or pt (p)/A		---% injury---		----------% control----------			
PMax+Etho / PMax+Etho	**28+4 /** **28+4**	B / C	5	10	59	74	63	100
PMax+Etho+Dual / PMax+Etho	**28+4+1.25p /** **28+4**	B / C	5	13	66	86	65	98
PMax+Etho+War / PMax+Etho	**28+4+3.25p /** **28+4**	B / C	10	0	87	94	95	100
PMax+Etho+Out/ PMax+Etho	**28+4+18 /** **28+4**	B / C	4	3	88	96	94	95
Dual / PMax+Etho+Dual / PMax+Etho	**0.5p / 28+4+1p /** **28+4**	A / B / C	0	3	98	92	91	99
Dual / PMax+Etho+War / PMax+Etho	**0.5p / 28+4+3p /** **28+4**	A / B / C	0	5	97	99	99	100
Dual / PMax+Etho+Out / PMax+Etho	**0.5p / 28+4+18 /** **28+4**	A / B / C	5	8	98	98	91	100
LSD (0.10)			**7**	**11**	**17**	**14**	**17**	**7**
CV			**308**	**189**	**19**	**14**	**19**	**6**

[1]Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v
[2]Application codes refer to the information in Table 1
[3]PMax=Roundup PowerMax; Dual=Dual II Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC

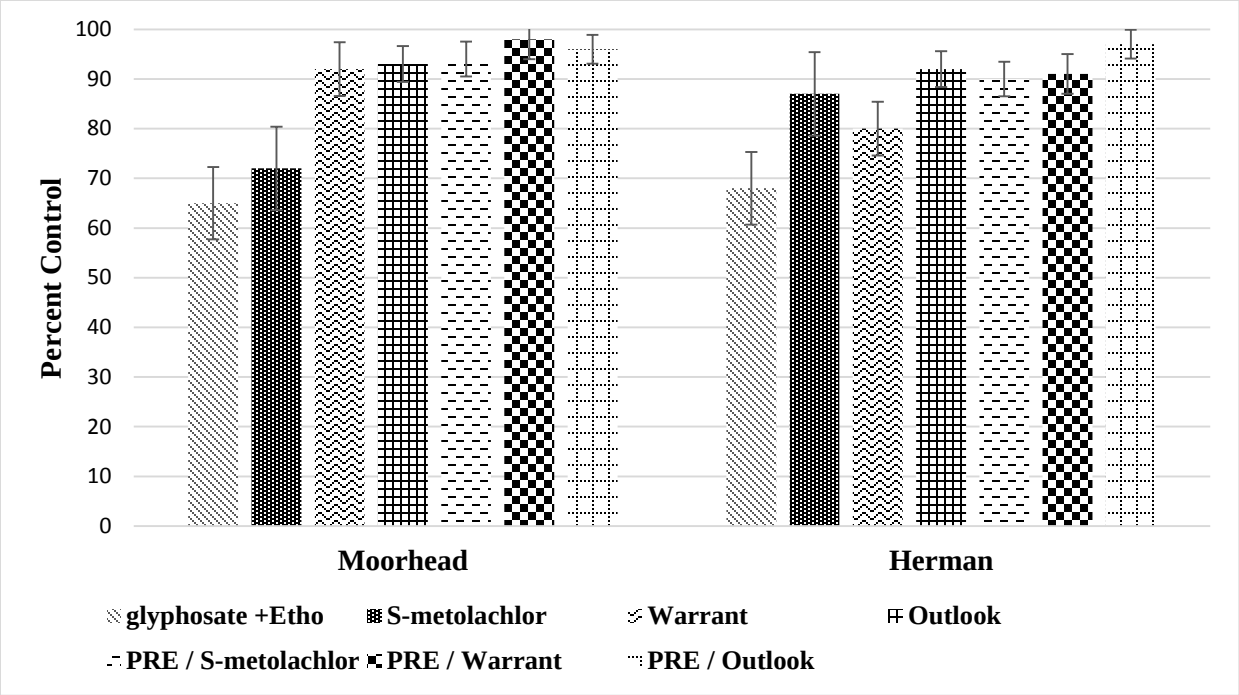

Figure 2. Waterhemp control[1] from lay-by herbicides[2] and PRE S-metolachlor followed by lay-by herbicides, at Herman, MN and Moorhead, MN in 2015.

[1]Standard deviation for herbicide comparisons by location

[2]Etho = ethofumesate

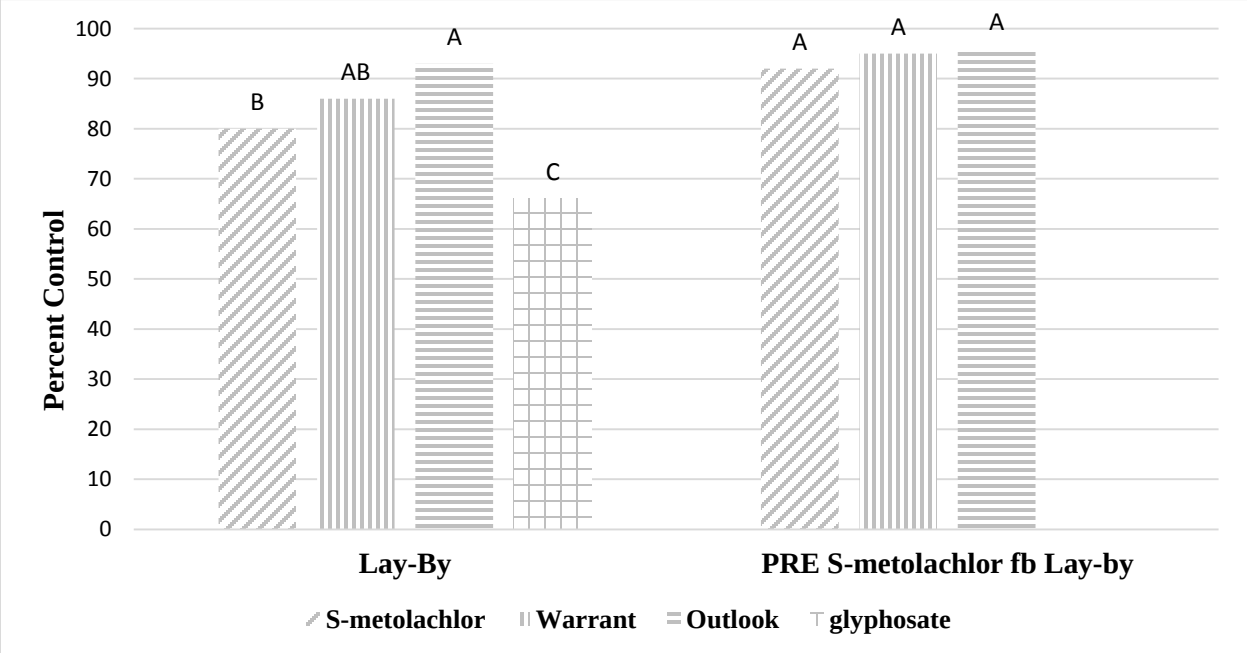

Figure 3. Waterhemp control from lay-by herbicides and PRE S-metolachlor followed by lay-by herbicides, averaged across Herman, MN and Moorhead, MN in 2015.

Sugarbeet planting date is the first consideration for waterhemp control recommendation (Table 9). Lay-by or split lay-by of chloroacetamide herbicides is the preferred approach for waterhemp control for early planted sugarbeet. Use PRE followed by a single lay-by application for fields with early germinating weeds or to manage the risk of uncertainty with activation of lay-by herbicide.

Late planted sugarbeet may not reach the sugarbeet 2-lf stage by May 15 or the date for lay-by application of chloroacetamide herbicides. Thus, S-metolachlor or ethofumesate should be applied PRE followed by lay-by. Timing of lay-by will be dependent on sugarbeet planting date, precipitation to activate PRE, and waterhemp pressure in the field.

Continue to scout sugarbeet fields for waterhemp in July and August. Tank-mixes of Betamix or UpBeet with Roundup plus ethofumesate are recommended for POST waterhemp control. Apply in combination with HSMOC at 1.5 pt/A and AMS at 8.5 to 17 lb/100 gallon water carrier.

Table 9. Recommendation for waterhemp control in sugarbeet, by planting date.

Planting Date	**Recommendation**
Plant Sugarbeet in April	Split application of chloroacteamide herbicides applied lay-by, 2-lf fb 4-6 lf
	Lay-by when sugarbeet is at the 2-lf stage or greater
	S-metolachlor or ethofumesate PRE followed by a single lay-by application
Plant Sugarbeet in May	S-metolachlor or ethofumesate PRE followed by a single lay-by at the full two leaf stage (4-lvs if PRE received good activating rainfall)
Mid July and August	Continue to scout fields for late germinating waterhemp
	Be prepared to rescue with Betamix + ethofumesate, UpBeet+ ethofumesate or Betamix + UpBeet

Future Research

2016 experiments will continue to explore a systems approach for waterhemp control that combines PRE and POST herbicides. The major focus will be on lay-by applications of soil-applied herbicides in sugarbeet. Waterhemp control and sugarbeet injury from lay-by applications will be compared to PRE followed by lay-by, split-layby, or PRE followed by split lay-by applications.

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