

## CONTINUED EVALUATION OF THE STRATEGY FOR MANAGING WATERHEMP IN SUGARBEET

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### Summary

1. Chloroacetamide herbicides (S-metolachlor, Warrant, Outlook) applied early postemergence (lay-by) are the most effective waterhemp control strategy in sugarbeet
2. Dual Magnum at 0.5 to 0.75 pt/A, ethofumesate at 1 to 2 pt/A) or Dual Magnum + ethofumesate at 0.5+ 2 pt/A) applied preemergence and followed by split application of S-metolachlor, Warrant or Outlook early postemergence provides the most consistent waterhemp control in sugarbeet.
3. Sugarbeet injury is least when chloroacetamide herbicides are split applied early postemergence and postemergence.

### Introduction

Sugarbeet growers across all sugarbeet producing regions in Minnesota and eastern North Dakota should be scouting for waterhemp. Waterhemp is a summer annual weed in the pigweed family that can germinate in mid to late May, June, and July in North Dakota and Minnesota. 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. Waterhemp plants have male and female flowers on separate plants thus increasing the 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 (SOA2), triazine (SOA5), PPO inhibitor (SOA14), and glyphosate (SOA9) in Minnesota and North Dakota.

Waterhemp germination and emergence is tracked using a growing degree day (GDD) model (base temperature 45F) that calculates GDD accumulation during calendar year. Three hundred fifty units correspondence with waterhemp emergence and generally occurs in mid to late May. However, improved awareness and recognition of waterhemp has challenged the accuracy and utility of the model. Extension personnel will continue to use the model but recognize that local weather conditions and field specific environments ultimate will determine waterhemp emergence date.

Field research conducted at multiple field locations in 2014 and 2015 has concluded the chloroacetamide herbicides (S-metolachlor, Outlook, and Warrant) applied early postemergence (lay-by) with glyphosate and ethofumesate provide the most consistent waterhemp control. Growers enjoyed very favorable conditions for timely sugarbeet planting in 2016. However, several variables including stand uniformity, crop stage of nurse crops, waterhemp germination and emergence, and lack of timely precipitation in May created challenges for execution of the lay-by waterhemp control strategy.

S-metolachlor applied PRE followed by lay-by application improved the consistency and overall waterhemp control in an experiment at Moorhead in 2015. Additional research needs to be conducted to evaluate the PRE fb EPOST concept. Outlook usually is applied split lay-by or 12 fl oz/A fb 12 fl oz/A compared to 18 or 21 fl oz/A. Additional research needs to be conducted to determine if S-metolachlor or Warrant should be split applied. The objectives of 2016 experiments were to evaluate sugarbeet safety and waterhemp control at multiple locations from: a) S-metolachlor applied PRE followed by S-metolachlor, Warrant, or Outlook lay-by in single or multiple application; b) S-metolachlor, Warrant, or Outlook lay-by in a single or multiple application and; c) S-metolachlor, Outlook and Warrant rates lay-by in single or multiple applications. The purpose of this report is to summarize the sugarbeet safety experiment conducted at Roseland, MN and the waterhemp control experiment conducted at Moorhead, MN in 2016.

## Materials and Methods

Experiments were conducted on natural populations of waterhemp near Moorhead and Roseland, Minnesota in 2016. Plot area was prepared with a Kongskilde s-tine field cultivator on May 7, 2016 at Moorhead, MN and with a field cultivator with rolling baskets on May 4, 2016 at Roseland, MN. Hilleshog ‘HM4302RR’ sugarbeet treated with Tachigaren, at 45 grams product, Cruiser Maxx (contains Cruiser 5FS at 60 gram active ingredient (g a.i.), Apron XL at 15 g a.i., and Maxim 4FS at 2.5 g a.i.) and Vibrance at 2g a.i. per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on May 12, 2016 at Moorhead. Crystal ‘M380’ sugarbeet treated with Tachigaren and Kabina at 45 g product and 14 g a.i. per 100,000 seeds, respectfully, was seeded 1.25 inches deep in 22 inch rows at 61,000 seeds per acre on May 5, 2016 at Roseland, MN

Herbicide treatments were applied at Moorhead May 16, June 6, and June 20, 2016 and May 5, June 2, and June 17, 2016 at Roseland. All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO<sub>2</sub> 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 June 24 and July 22, 2016 at Moorhead, MN and June 10, June 23, and July 5, 2016 at Roseland, MN. Waterhemp control was evaluated June 24, June 28, July 22, and August 24, 2016 at Moorhead and June 10, June 23, and July 5, 2016 at Roseland. Common lambsquarters and redroot pigweed control also was evaluated at each location but not included in this report since glyphosate provided complete or near complete control. 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 2016.4 software package.

**Table 1. Application information for sugarbeet trials near Roseland, MN in 2016.**

Application code	A	B	C
Date	May 5	June 2	June 17
Time of Day			
Air Temperature (F)	61	74	70
Relative Humidity (%)	36	40	40
Wind Velocity (mph)	7	4	10
Wind Direction	SW	W	SE
Soil Temp. (F at 6")	-	-	-
Soil Moisture	Good	Fair	Very Wet
Cloud Cover (%)	40	-	-
Sugarbeet stage (avg)	PRE	2-4	8-10
Waterhemp	-	-	-

**Table 2. Application information for sugarbeet trial near Moorhead, MN in 2016.**

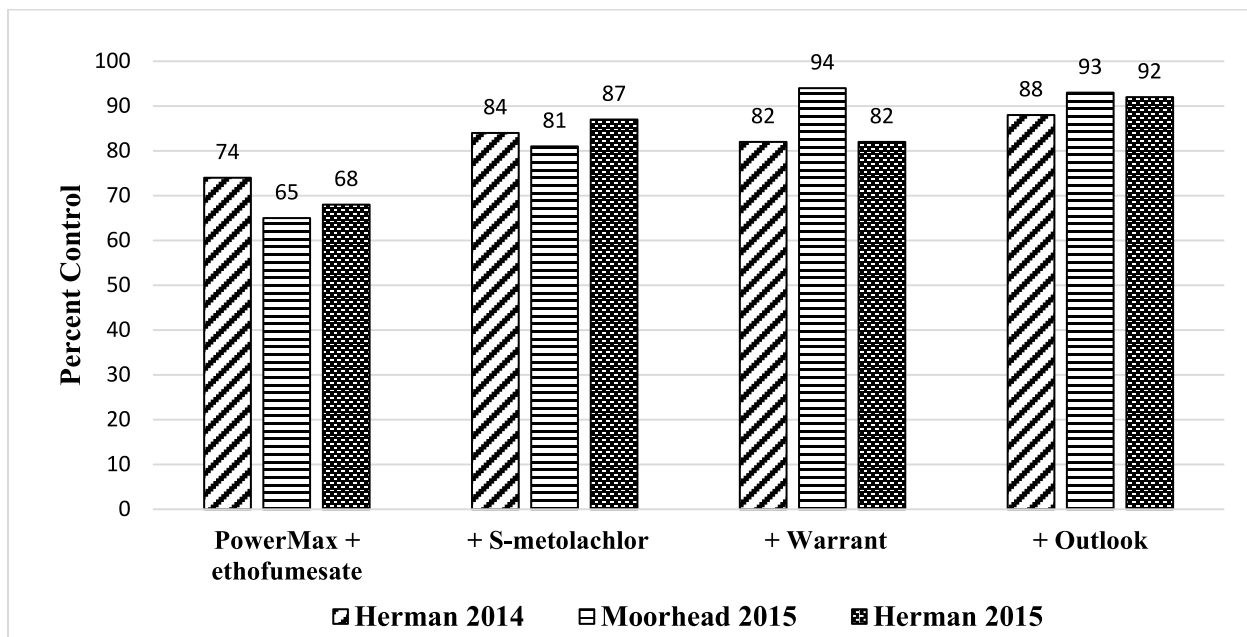
Application code	A	B	C
Date	May 16	June 6	June 20
Time of Day	9:00 AM	2:00 PM	2:30 PM
Air Temperature (F)	51	67	73
Relative Humidity (%)	56	56	37
Wind Velocity (mph)	7	12	10
Wind Direction	N	NW	NW
Soil Temp. (F at 6")	48	62	70
Soil Moisture	Poor	Good	Good
Cloud Cover (%)	80	90	10
Sugarbeet stage (avg)	PRE	4-6 lf	10 lf
Waterhemp	-	0.5"	1-3"

## Results and Discussion

**2014 and 2015.** Lay-by is use of soil residual 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.

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 or POST only tank-mixtures (1, 2). 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, more easily activated (3). 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.

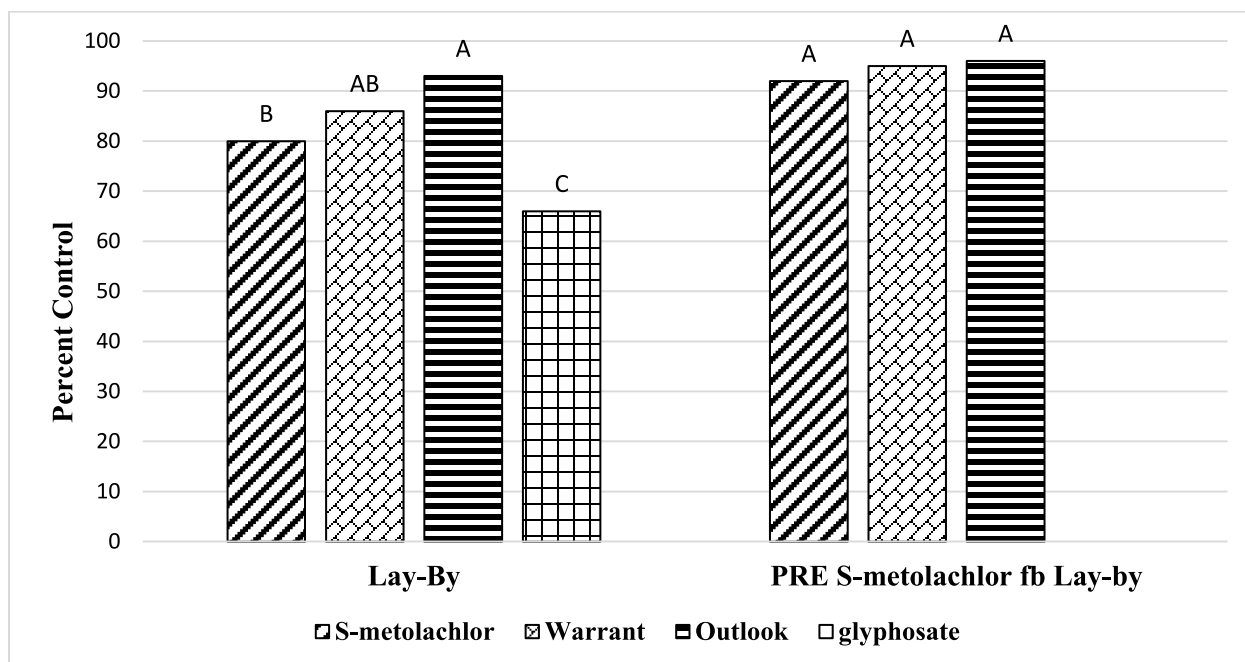


**Figure 1. Waterhemp control from glyphosate plus ethofumesate and lay-by herbicides at different locations in 2014 and 2015.**

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 improved the consistency of waterhemp control at Herman and Moorhead in 2015 (Figure 2). Waterhemp control tended to be greater when S-metolachlor was applied PRE fb lay-by, compared to lay-by alone.

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.



**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.**

**2016.** Herbicides applied lay-by in single or multiple applications (split-lay-by) or PRE fb lay-by or split lay-by did not injure sugarbeets at Moorhead in 2016 (Table 2). This continues a trend of negligible sugarbeet injury from use of chloroacetamide herbicides alone or tank-mixed with glyphosate + ethofumesate. Lay-by applications were applied later than usual and at a higher growth stage (up to 6-lf sugarbeet) to achieve full stands since germination and emergence was confounded by dry soil conditions.

Waterhemp control was influenced by herbicide and application timing but generally was not influenced by herbicide rate (Table 2, Figure 4). Waterhemp control was best when S-metolachlor was applied PRE and followed by lay-by or split lay-by application. Timing of lay-by application may have impacted these results as the delay in application to achieve desired sugarbeet stage before application provided greater time for waterhemp to germinate and emerge, even though glyphosate + ethofumesate was in the tank-mix for burndown control. Previous experience and data from this experiment indicates glyphosate + ethofumesate alone do not provide sufficient waterhemp control, especially once waterhemp is greater than 1-inch. Splitting the lay-by application tended to improve waterhemp control as compared to a single application. Improvement in waterhemp control tended to occur across chloroacetamide herbicide. Outlook split lay-by at 12+12 fl oz/A is the common application approach by Growers, generally favoring this approach to a single application of 15 to 21 fl oz/A.

Common lambsquarters control was outstanding at Moorhead (data not presented). Control ranged from 95 to 100% across treatments. A uniform infestation of lambsquarters was 2 inches tall at application. Lambsquarters control was evaluated only on June 24 due to magnitude of control and competition from sugarbeet and waterhemp.

There was significant sugarbeet injury at Roselawn (Table 3). Sugarbeet injury was characterized as growth reduction injury, sugarbeet a pale green color compared to untreated sugarbeet, and lack of sugarbeet uniformity within the row. Injury across treatments ranged from 14 to 51% on June 10, from 6 to 30% on June 23, and from 5 to 21% on July 5, 8, 28, and 33 days, respectfully, after the first lay-by application. Average sugarbeet injury across treatments was 29%, 25%, and 14% on June 10, June 23 and July 5, respectfully.

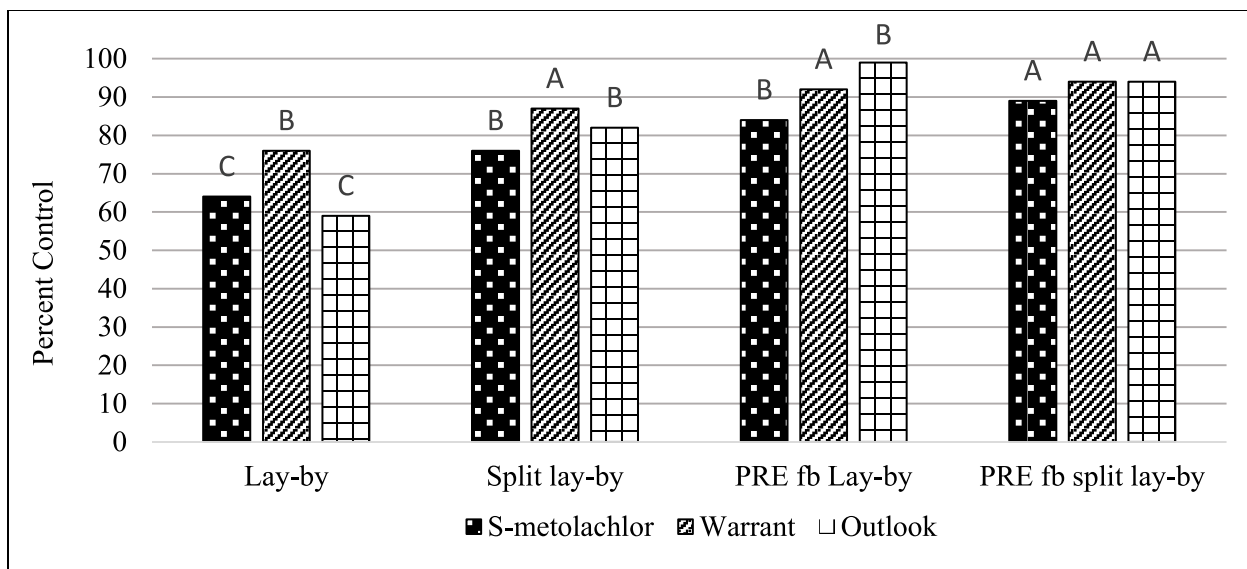
**Table 2. Sugarbeet injury and waterhemp control from lay-by herbicide treatments at Moorhead, MN in 2016.**

Treatment <sup>1</sup>	Rate fl oz or pt (p)/A	App. Code <sup>2</sup>	Sugarbeet		Waterhemp		
			Jun 24 ---% injury---	Jul 22	Jun 24 -----% control-----	Jul 22	Aug 24
PMax <sup>3</sup> +Etho / PMax+Etho	28+4 / 28+4	B / C	0	1	0	45	33
PMax+Etho+Dual / PMax+Etho	28+4+1.25p / 28+4	B / C	0	0	71	68	60
PMax+Etho+Dual / PMax+Etho	28+4+1.67p / 28+4	B / C	0	0	74	60	55
PMax+Etho+War / PMax+Etho	28+4+3.25p / 28+4	B / C	0	0	88	78	75
PMax+Etho+War / PMax+Etho	28+4+4p / 28+4	B / C	0	0	90	79	74
PMax+Etho+Out / PMax+Etho	28+4+18 / 28+4	B / C	0	0	78	64	55
PMax+Etho+Out / PMax+Etho	28+4+21 / 28+4	B / C	0	4	81	73	64
PMax+Etho+Dual / PMax+Etho+Dual	28+4+1p / 28+4+1p	B / C	5	0	84	80	71
PMax+Etho+Dual / PMax+Etho+Dual	28+4+1.25p / 28+4+1.25p	B / C	0	3	90	89	85
PMax+Etho+War / PMax+Etho+War	28+4+2.25p / 28+4+2.25p	B / C	0	3	93	88	86
PMax+Etho+War / PMax+Etho+War	28+4+3p / 28+4+3p	B / C	0	3	86	86	85
PMax+Etho+Out / PMax+Etho+Out	28+4+12 / 28+4+12	B / C	0	0	88	86	78
PMax+Etho+Out / PMax+Etho+Out	28+4+15 / 28+4+9	B / C	0	0	83	81	70
Dual / PMax+Etho+Dual / PMax+Etho	0.5p / 28+4+1.25p / 28+4	A / B / C	0	0	90	84	84
Dual / PMax+Etho+War / PMax+Etho	0.5p / 28+4+3.25p / 28+4	A / B / C	0	0	99	93	91
Dual / PMax+Etho+Out / PMax+Etho	0.5p / 28+4+18 / 28+4	A / B / C	0	5	100	98	100
Dual / PMax+Etho+Dual / PMax+Etho+Dual	0.5p / 28+4+1p / 28+4+1p	A / B / C	0	0	91	91	88
Dual / PMax+Etho+War / PMax+Etho+Dual	0.5p / 28+4+2.25p / 28+4+2.25p	A / B / C	0	0	94	95	94
Dual / PMax+Etho+Out / PMax+Etho+Dual	0.5p / 28+4+9 / 28+4+9	A / B / C	0	0	96	94	95
LSD (0.05)			3	4	10	13	13
CV			879	341	8	12	12

<sup>1</sup>Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v

<sup>2</sup>Application codes refer to the information in Table 1

<sup>3</sup>PMax=Roundup PowerMax; Dual=Dual Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC



**Figure 4. Waterhemp control from single (lay-by) or multiple applications of herbicides applied lay-by (split-lay-by) or PRE S-metolachlor followed by a lay-by or split lay-by, Moorhead, MN in 2016, average of July 22 and August 24 evaluation.**

Sugarbeet injury was influenced by herbicide treatment, herbicide rate, timing of treatment application, and evaluation timing. Injury was greatest at the first evaluation timing or 8 days after PRE application. Injury tended to decrease in time from June 10 to July 5, the final evaluation. Injury was most severe from S-metolachlor PRE fb S-metolachlor, Outlook or Warrant lay-by (Figure 5). Splitting the lay-by application or a single lay-by application decreased or tended to decrease sugarbeet injury. Sugarbeet injury from S-metolachlor or Warrant was the same and was less or tended to be less than sugarbeet injury from Outlook. Greater injury from Outlook might be related to the amount and timeliness of precipitation and the solubility of Outlook. These data provide good evidence for splitting Outlook lay-by compared to an 18 or 21 fl oz Outlook in a single application lay-by.

Experiment was very unique due to the amount and timeliness of precipitation. It is likely that chloroacetamide herbicide was leached into the seedling zone of actively growing plants. The outcome were plants that were not actively growing; plants that were standing still; plants that were drunk. The experiment received 10.6 inches of precipitation in May and June, the first eight weeks following planting. Over one-inch precipitation occurred in a single rainfall event five days following PRE, 11 days following lay-by and the day following split lay-by application. The experiment was planted into corn stalks residue.

Experiment does not suggest that chloroacetamide herbicides applied PRE and/or lay-by will always cause sugarbeet injury. Rather, the experiment informs its audience that when conditions are appropriate for sugarbeet injury, S-metolachlor PRE fb S-metolachlor, Outlook or Warrant lay-by will cause the greatest sugarbeet injury. It teaches that Outlook has the potential to cause more injury than Dual Magnum or Warrant.

Experiment reinforces our herbicide rate structure. Dual Magnum should be applied at 1.25 pt/a lay-by or 1 pt/a fb 1 pt/a split lay-by; Warrant 3.25 pt/a or 2.25 pt/a fb 2.25 pt/a; and Outlook 18 oz or 12 oz/a fb 12 oz/a split lay-by.

Waterhemp control ranged from 85 to 100% during the June 23 and July 5 evaluations (Table 3). Waterhemp control from lay-by herbicide application was slightly better than split-lay-by herbicide application but was herbicide treatment dependent. S-metolachlor applied PRE tended to improve control provided from lay-by treatments. However, control tended to be greater from lay-by herbicide application than split-lay-by application.

In general, there were no differences across herbicides, herbicide rates or application timing. Lambsquarters control was near perfect there were no observations of treatment differences (data not presented). There was a light infestation of redroot pigweed in the experimental area (data not presented). In general, all entries provided greater than 95% pigweed control. Lay-by tended to provide slightly better control than split-lay-by. PRE fb lay-by or PRE fb split lay-by gave perfect pigweed control.

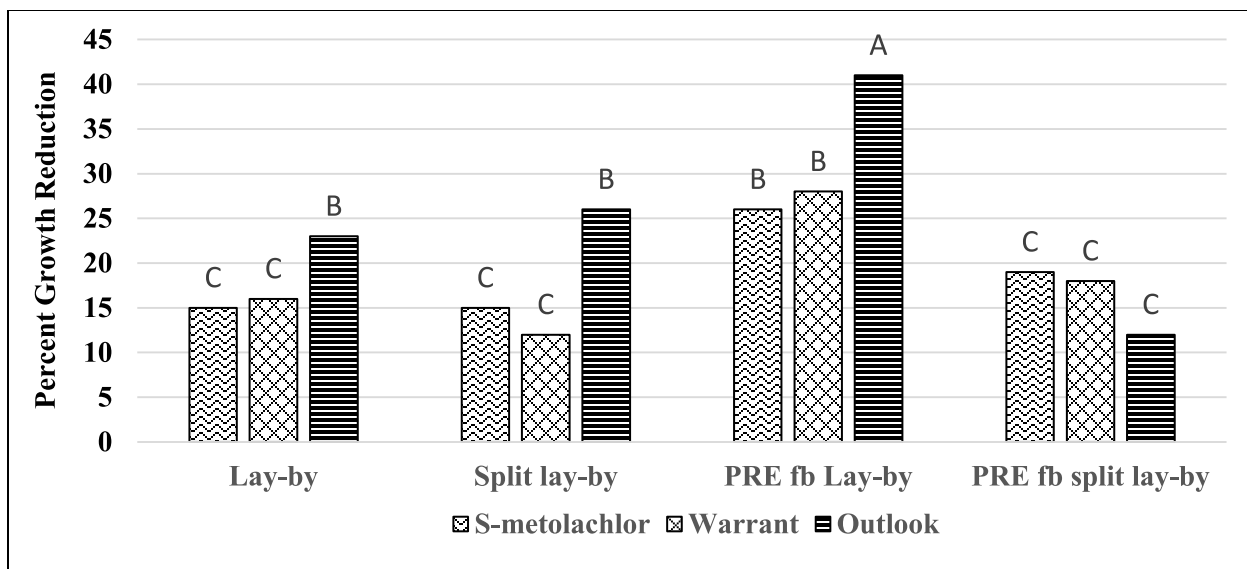
**Table 3. Sugarbeet injury and waterhemp control from lay-by herbicide treatments at Roseland, MN in 2016.**

Treatment <sup>1</sup>	Rate fl oz or pt (p)/A	App. Code <sup>2</sup>	Sugarbeet			Waterhemp	
			Jun 10	Jun 23	Jul 5	Jun 23	Jul 5
			-----% injury-----			--% control--	
PMax <sup>3</sup> +Etho /	28+4 /	B /					
PMax+Etho	28+4	C	0	0	9	70	64
PMax+Etho+Dual /	28+4+1.25p /	B /					
PMax+Etho	28+4	C	25	5	11	90	65
PMax+Etho+Dual /	28+4+1.67p /	B /					
PMax+Etho	28+4	C	38	20	6	96	93
PMax+Etho+War /	28+4+3.25p /	B /					
PMax+Etho	28+4	C	16	15	5	99	95
PMax+Etho+War /	28+4+4p /	B /					
PMax+Etho	28+4	C	41	14	11	98	95
PMax+Etho+Out / PMax+Etho	28+4+18 /	B /					
	28+4	C	38	8	11	95	93
PMax+Etho+Out / PMax+Etho	28+4+21 /	B /					
	28+4	C	39	23	19	98	96
PMax+Etho+Dual /	28+4+1p /	B /					
PMax+Etho+Dual	28+4+1p	C	18	13	11	88	85
PMax+Etho+Dual /	28+4+1.25p /	B /					
PMax+Etho+Dual	28+4+1.25p	C	21	10	14	95	91
PMax+Etho+War /	28+4+2.25p /	B /					
PMax+Etho+War	28+4+2.25p	C	14	10	11	85	89
PMax+Etho+War /	28+4+3p /	B /					
PMax+Etho+War	28+4+3p	C	35	19	13	98	96
PMax+Etho+Out /	28+4+12 /	B /					
PMax+Etho+Out	28+4+12	C	34	18	18	96	95
PMax+Etho+Out /	28+4+15 /	B /					
PMax+Etho+Out	28+4+9	C	26	6	6	100	100
Dual / PMax+Etho+Dual /	0.5p / 28+4+1.25p /	A / B /					
PMax+Etho	28+4	C	36	15	18	100	100
Dual / PMax+Etho+War /	0.5p / 28+4+3.25p /	A / B /					
PMax+Etho	28+4	C	39	16	18	99	99
Dual / PMax+Etho+Out /	0.5p / 28+4+18 /	A / B /					
PMax+Etho	28+4	C	51	30	21	100	100
Dual / PMax+Etho+Dual /	0.5p / 28+4+1p /	A / B /					
PMax+Etho+Dual	28+4+1p	C	20	19	19	99	93
Dual / PMax+Etho+War /	0.5p / 28+4+2.25p /	A / B /					
PMax+Etho+Dual	28+4+2.25p	C	23	13	15	100	96
Dual / PMax+Etho+Out /	0.5p / 28+4+9 /	A / B /					
PMax+Etho+Dual	28+4+9	C	15	9	13	98	98
LSD (0.05)			16	14	9	8	11
CV			40	72	48	6	9

<sup>1</sup>Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v

<sup>2</sup>Application codes refer to the information in Table 1

<sup>3</sup>PMax=Roundup PowerMax; Dual=Dual II Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC



**Figure 5. Sugarbeet injury from single (lay-by) or multiple applications of herbicides applied lay-by (split-lay-by) or PRE S-metolachlor followed by a lay-by or split lay-by, Moorhead, MN in 2016, average of June 10 and June 23 evaluation.**

## Conclusions

Sugarbeet planting date is the first consideration for waterhemp control recommendation (Table 9). Lay-by or split lay-by application of chloroacetamide herbicides is the preferred approach for waterhemp control for early planted sugarbeet. Use PRE followed by a split 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 approximate date for waterhemp germination and emergence and lay-by application of chloroacetamide herbicides. Thus, Dual Magnum or ethofumesate should be applied PRE followed by split 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 4. Recommendation for waterhemp control in sugarbeet, by planting date.**

Planting Date	Recommendation
<b>Plant Sugarbeet in April</b>	Split lay-by application (early postemergence / postemergence) of chloroacetamide herbicides applied at 2-lf sugarbeet fb 4 to 6-lf sugarbeet
	Single lay-by application when sugarbeet is at the 2-lf stage or greater
	Dual Magnum and/or ethofumesate PRE followed by a split lay-by application at 2 to 4-lf stage fb 4 to 6-lf stage
<b>Plant Sugarbeet in May</b>	Dual Magnum and/or ethofumesate PRE followed by a split lay-by
<b>Mid July and August</b>	Continue to scout fields for late germinating waterhemp
	Be prepared to rescue with Betamix + ethofumesate, UpBeet+ ethofumesate or Betamix + UpBeet

## Future Research

Sugarbeet growers have asked about cultivation as an integrated management strategy to achieve the zero tolerance for weed escapes strategy. We need to investigate if cultivation will disrupt the herbicide boundary, allowing new flushes of waterhemp to germination and emerge, thus potentially doing more harm than good. We need to

investigate if cultivation is a method to activate lay-by herbicides when precipitation is not timely. We need to evaluate if Treflan is an effective option for lay-by control of waterhemp in sugarbeet.

We need to continue to evaluate the preemergence component of the systems strategy for waterhemp control. We need to determine if ethofumesate should be utilized in tank-mixtures with Dual Magnum to extend waterhemp control. We need to continue to evaluate formulation technology that may permit preemergence use of Ro-Neet SB in sugarbeet.

#### **Literature Cited**

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3. Weed Science Society of America (2014) Herbicide Handbook. 5<sup>th</sup> ed. Shaner DL. ed. Lawrence, KS: Weed Science Society of America. 513 p.