Gold Section: Sugarbeet Weed Control

CONTINUED REFINEMENT OF THE WATERHEMP CONTROL STRATEGY IN SUGARBEET

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SUMMARY

1. Chloroacetamide herbicide application timing tended to have a greater effect on waterhemp control than choice of chloroacetamide herbicide.
2. Split application of chloroacetamide herbicides improved waterhemp control compared to a single chloroacetamide herbicide application.
3. Applying Dual Magnum preemergence (PRE) fb a chloroacetamide herbicide lay-by improved waterhemp control compared to chloroacetamide alone.
4. Lambsquarters control from glyphosate + ethofumesate was not affected by chloroacetamide herbicide applied with glyphosate and ethofumesate (data not presented).

INTRODUCTION

Survey data indicates waterhemp is the primary weed control challenge in sugarbeet fields in Southern Minnesota Beet Sugar Cooperative, in Minn-Dak Farmers' Cooperative, and in fields south of Grand Forks in American Crystal Sugar Cooperative. Waterhemp populations are a mixture of glyphosate susceptible and resistant biotypes. Roundup PowerMax at 28 fl oz/A controlled 78% of the first flush of emerged waterhemp based on waterhemp counts taken immediately prior to and 9 days following application (Peters, 2015). However, control does not improve by increasing the glyphosate rate or with repeat glyphosate applications. Early-season weed escapes cause late-season weed control failures and weed disasters at harvest. There are no effective POST herbicide options for rescue control of resistant biotypes, especially when waterhemp is greater than 4-inches tall.

Ethofumesate or Ro-Neet provide effective early-season waterhemp control but are expensive or do not provide full-season control (Peters, 2016). Use of site of action (SOA) 15 herbicides (chloroacetamides) applied early postemergence (EPOST) provide the most effective and consistent waterhemp control (Peters, 2015; Peters, 2016; Peters, 2017). However, several important statements should be made about chloroacetamide herbicides and waterhemp control. First, sugarbeet must reach the 2-leaf stage before chloroacetamides can be applied. Thus, planting date influences how and when they can be applied. Second, chloroacetamides need to be activated by timely precipitation in order to control waterhemp. Third, waterhemp seems to be emerging earlier in the spring. Are we selecting for earlier germinating biotypes or have we improved awareness and identification? Maybe some of both. Finally, sugarbeet grower surveys indicate approximately 85% satisfaction (excellent or good response) with current waterhemp control strategies. How can we improve satisfaction to 90% or 95%?

Waterhemp control in soybean was improved using repeat application of chloroacetamide herbicides; a practice referred to as 'layering' (Steckel, 2002). Sugarbeet experiments conducted at Herman and Moorhead, MN in 2015 investigate repeat applications of chloroacetamide herbicides in sugarbeet. Dual Magnum (s-metolachlor) at 0.5 pt/A was applied PRE followed by glyphosate + ethofumesate plus either S-metolachlor, Warrant or Outlook at 2-lf sugarbeet stage. Waterhemp control averaged greater than 90% using the layering strategy compared to S-metolachlor, Warrant, or Outlook applied EPOST (Figure 1).

Outlook often is split-applied at 12 fl oz/A at the 2-leaf sugarbeet stage followed by 12 fl oz/A at the 6-leaf stage. This practice is common when glyphosate plus Outlook is tank-mixed with an insecticide for black cutworm control since there is a concern that applying multiple products formulated as emulsifiable concentrates may injury sugarbeet, especially under cold and wet spring environmental conditions. Split application can also improve waterhemp control consistency (conversation with Jim Radermacher, 2015). Split lay-by application buffers against the possibility of inadequate or untimely precipitation since the first application in May is followed by a second application, 14 to 21 days later, in June.

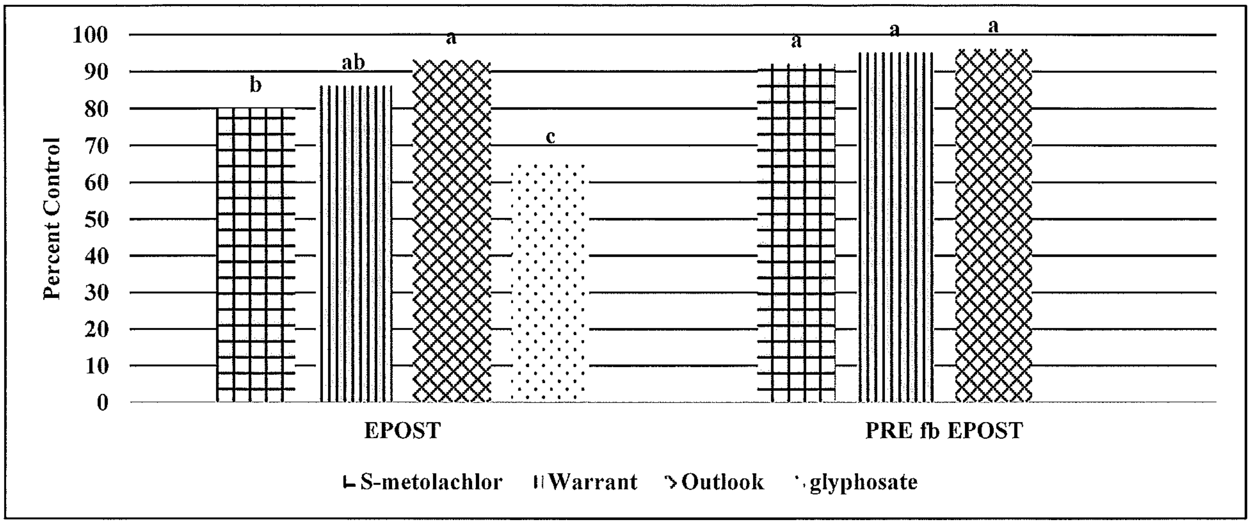

Figure 1. Waterhemp control from soil-residual herbicides applied early postemergence (EPOST) or S-Metolachlor at 0.5 pt/A preemergence (PRE) followed by soil-residual herbicides applied EPOST, averaged across Herman and Moorhead, MN, 2015.

Following successes with Outlook, sugarbeet growers and Agriculturalists have asked if Warrant and S-metolachlor should also be split-applied. The objectives of 2016 and 2017 experiments were to evaluate sugarbeet safety and waterhemp control at multiple locations from: a) Dual Magnum PRE-followed by S-metolachlor, Warrant, or Outlook EPOST in single or multiple applications and; b) S-metolachlor, Warrant, or Outlook EPOST in single or multiple applications. This report summarizes experiments conducted at Roseland, MN in 2016 and Lake Lillian, MN, and Galchutt, ND in 2017.

MATERIALS AND METHODS

Experiments were conducted on natural populations of waterhemp near Moorhead, MN in 2016 and Lake Lillian, MN and Galchutt, ND in 2017. Experimental area was prepared using a field cultivator prior to planting. 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 0.5 inches deep in 22 inch rows at 62,100 seeds per acre on May 8, 2017 at Lake Lillian, MN. 'HM4022RR' 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 9, 2017 at Galchutt.

Table 1. 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 inch	1-3 inch

Herbicide treatments were applied at Moorhead on May 16, June 6, and June 20, 2016; May 11, June 1, and June 16, 2017 at Lake Lillian, and May 9, June 1, and June 20, 2017 at Galchutt. 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 United. 'Destiny HC' high surfactant methylated oil concentrate (HSMOC) was also used and is a product from Winfield United.

Table 2. Application information for sugarbeet trial near Lake Lillian, MN in 2017.

Application code	A	B	C
Date	May 11	June 1	June 16
Time of Day	9:00 AM	9:00 AM	9:00 AM
Air Temperature (F)	58	70	79
Relative Humidity (%)	27	27	42
Wind Velocity (mph)	12	3	5-10
Wind Direction	NNW	SSW	SSE
Soil Temp. (F at 6")	68	70	-
Soil Moisture	Good	Good	Good
Cloud Cover (%)	-	-	Partly Cloudy
Sugarbeet stage (avg)	PRE	2-4 lf	6-8 lf
Waterhemp	-	0.5 inch	1-3 inch

Sugarbeet injury was evaluated June 24 and July 22, 2016 at Moorhead, June 6, June 26 and July 6, 2017 at Lake Lillian, and June 16, 2017 at Galchutt. Waterhemp control was evaluated June 24, June 28, July 22, and August 24, 2016 at Moorhead, June 15, June 26 and July 6, 2017 at Lake Lillian and June 16, July 5, and July 24, 2017 at Galchutt. Common lambsquarters and redroot pigweed control also was evaluated at each location, but data are not included in this report since glyphosate provided complete or near complete control of both species. 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 2017.4 software package.

Table 3. Application information for sugarbeet trial near Galchutt, ND in 2017.

Application code	A	B	C
Date	May 9	June 1	June 20
Time of Day	12:00 PM	9:00 AM	12:00 PM
Air Temperature (F)	64	70	68
Relative Humidity (%)	37	32	47
Wind Velocity (mph)	10	3	6
Wind Direction	NW	S	NW
Soil Temp. (F at 6")	54	59	64
Soil Moisture	Good	Good	Good
Cloud Cover (%)	50	10	10
Sugarbeet stage (avg)	PRE	2-lf	8-10 lf
Waterhemp	-	1 inch	2 inch

RESULTS

Waterhemp control was influenced by herbicide and application timing at Moorhead in 2016 and Lake Lillian and Galchutt in 2017 (Figure 2, Figure 3, Figure 4). In general, application timing had greater influence on waterhemp control than chloroacetamide herbicide.

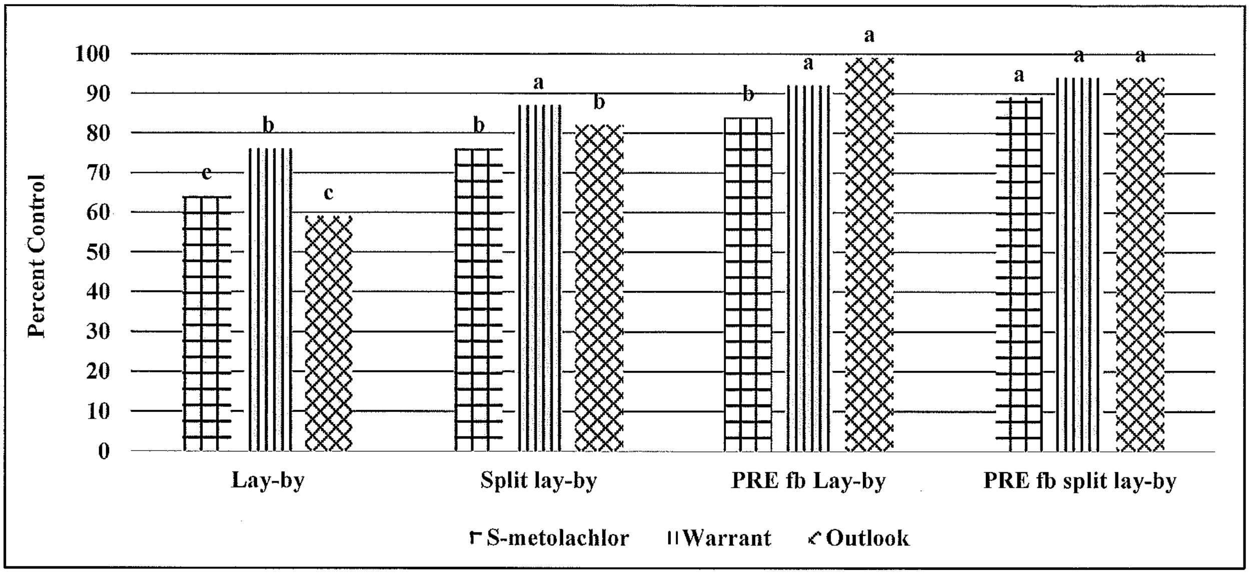

Figure 2. Waterhemp control from single lay-by or split lay-by herbicide applications and S-metolachlor preemergence (PRE) followed by lay-by or split lay-by herbicide applications, Moorhead, MN in 2016, average of July 22 and August 24 evaluation.

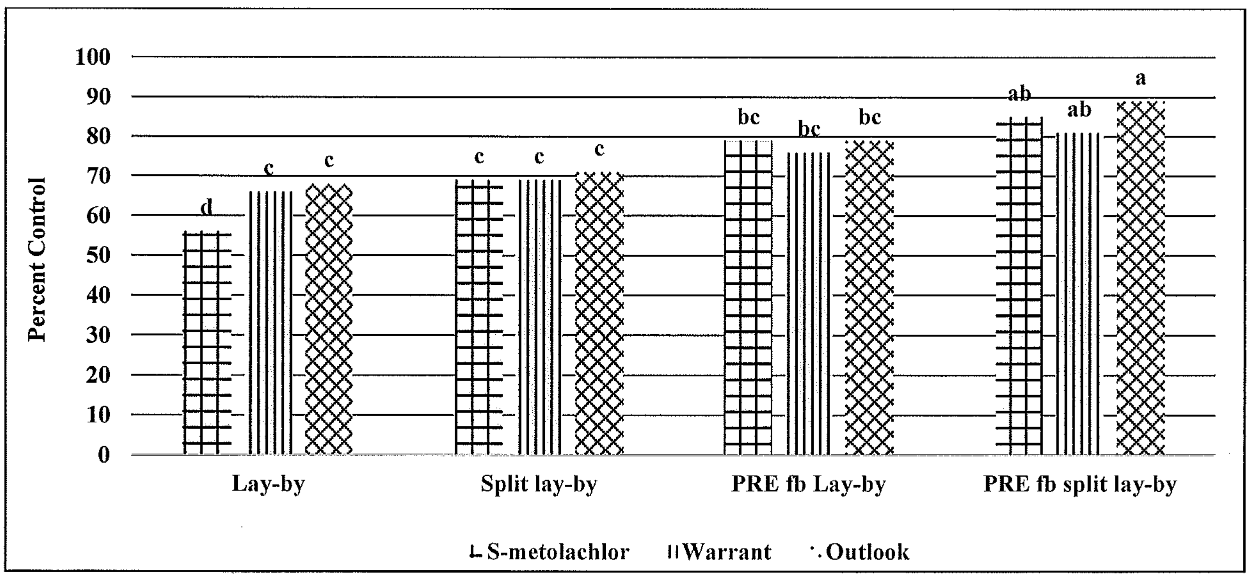

Figure 3. Waterhemp control from single lay-by or split lay-by herbicide applications and S-metolachlor preemergence (PRE) followed by lay-by or split lay-by herbicide applications, Lake Lillian, MN, 2017, July 6 evaluation.

There are several factors to consider when selecting a chloroacetamide herbicide for waterhemp control aside from relationships with a company or company representatives. Warrant costs less per acre on a rate basis than Outlook or S-metolachlor. Outlook is more water soluble than either S-metolachlor or Warrant and requires less precipitation for activation. Once activated, Warrant has longer residual than Outlook or S-metolachlor. Outlook and Warrant have a broader weed control spectrum than S-metolachlor. However, sugarbeet can be planted directly into S-metolachlor residues in the event of replant whereas three to four weeks' time is required before residue levels of Outlook and Warrant will allow sugarbeet replanting. Finally, S-metolachlor and Warrant are safer on sugarbeet than Outlook although injury generally is negligible with all chloroacetamide herbicides. Most of the factors to consider when selecting a chloroacetamide herbicide are based more around risk of sugarbeet injury than level of waterhemp control.

Waterhemp control from chloroacetamide herbicides was evaluated across locations in 2014 to 2017. Precipitation followed within 7-days of chloroacetamide activation in 2014 and 2015. However, timely precipitation did not occur in 2016 or 2017. 2016 was a dry spring, creating erratic germination and emergence patterns in experiments and in grower fields. Early postemergence chloroacetamide application was delayed five days to account for erratic emergence at the Moorhead location. Likewise, precipitation was spotty and possibly up to 24 days between the precipitation event that activated PRE herbicides and precipitation events to activate lay-by herbicides in 2017 at Lake Lillian. These climate phenomena partially explain waterhemp control observations in fields in 2016 and 2017 (Figure 2 and Figure 3).

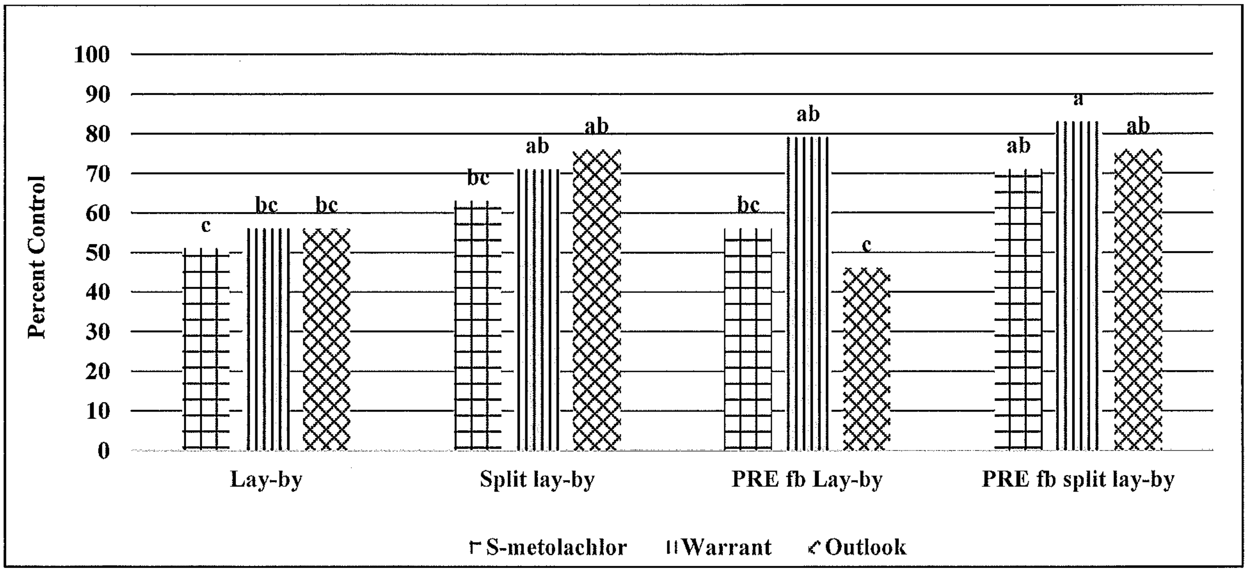

Figure 4. Waterhemp control from single lay-by or split lay-by herbicide applications and S-metolachlor preemergence (PRE) followed by lay-by or split lay-by herbicide applications, Galchutt, ND, 2017, July 25 evaluation.

The Galchutt, ND location received timely precipitation for activation of herbicides in 2017 (Figure 4). However, there was significant sugarbeet stand loss caused by rhizoctonia root rot, possibly caused by above average precipitation in June and July. Stand loss created an open canopy suitable for waterhemp germination and emergence well into July. Under these conditions, split application of chloroacetamide herbicides (EPOST fb POST) or PRE followed by split applications of chloroacetamide herbicides tended to provide better waterhemp control than single lay-by application of chloroacetamide herbicide alone or following PRE S-metolachlor.

At each of the three locations, 12 different treatment combinations of herbicide (S-metolachlor, Warrant, and Outlook) and timing (lay-by, split lay-by, PRE fb lay-by, and PRE fb split lay-by) were tested for a total of 36 observable treatments. In an effort to compare these treatments and determine which method of application resulted in the greatest and most constant control across locations, the following steps were taken. At each evaluation from each location, waterhemp control data was ranked in numerical order from greatest control to least control based upon the least significant difference (LSD). Herbicide treatments that were statistically the same as the best treatment at each evaluation timing from each location were grouped into a cluster and labeled 'good'. The remaining treatments were once again ranked and grouped into a second and third cluster based on LSD value and labeled 'fair' and 'poor', respectively. Clusters were titled 'good', 'fair' and 'poor' since treatments in the good cluster generally corresponded to 80% or greater waterhemp control, the fair cluster corresponded to 80 to 65% waterhemp control, and the poor cluster corresponded to 65 to 40% waterhemp control. Chloroacetamide herbicides were combined and were grouped by application timing into four classes: lay-by, split lay-by, PRE fb lay-by, and PRE fb split lay-by. The number of observations corresponding to each cluster (good, fair, or poor) were summed and are presented in Figure 5. Data indicates PRE fb lay-by and PRE fb split lay-by application methods provided the most consistent waterhemp control across locations and years.

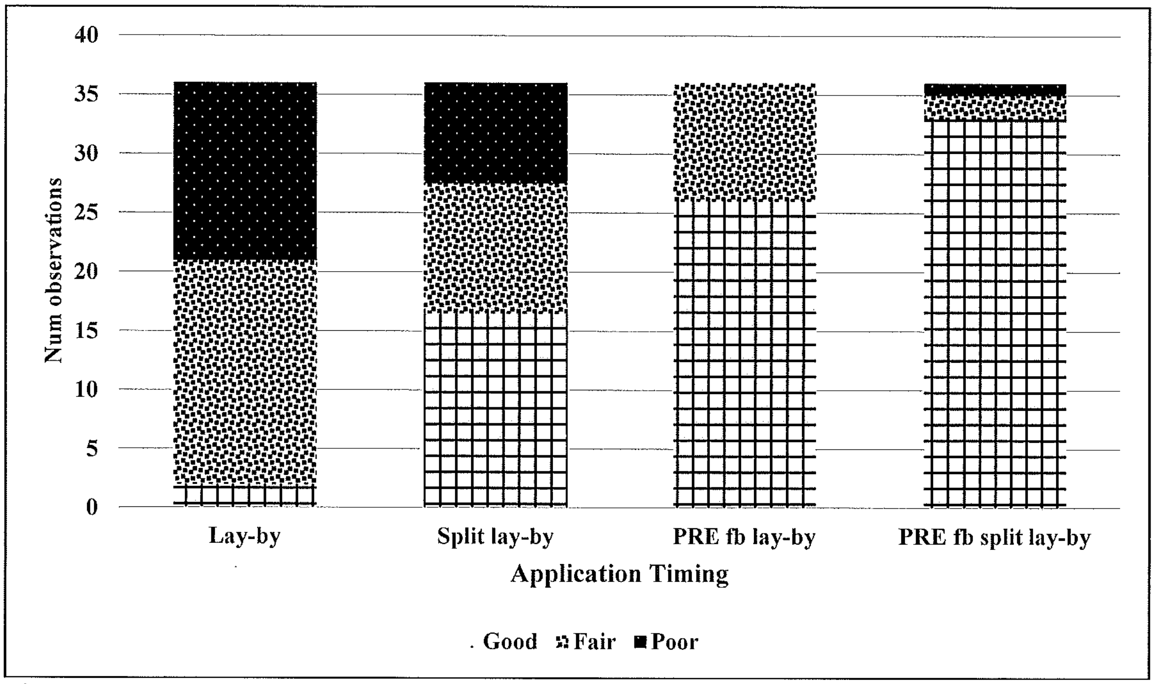

Figure 5. Number of good, fair, and poor estimates of waterhemp control across herbicides and application timing, summed across evaluations, locations, and years

CONCLUSIONS

Sugarbeet planting date is likely the most important factor to consider for herbicide selection and application timing for waterhemp control (Table 4). Split lay-by application of chloroacetamide herbicides is the preferred approach for waterhemp control for early planted sugarbeet. However, PRE followed by a split lay-by application buffers risk against early germinating weeds or uncertainty of when precipitation will occur to activate lay-by herbicides, even in early planted sugarbeet.

Late planted sugarbeet may not reach the sugarbeet 2-lf stage by May 15 (date when the growing degree day model typically forecasts waterhemp germination and emergence). Thus, Dual Magnum and/or ethofumesate should be applied PRE followed by split lay-by application of chloroacetamide herbicides. Timing of the lay-by applications 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 or cultivation are recommended for POST waterhemp control. Apply in combination with HSMOC adjuvant 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
Plant Sugarbeet in April	Split lay-by application (early postemergence / postemergence) of chloroacetamide herbicides applied at 2-lf sugarbeet fb 4 to 6-lf sugarbeet
	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
	Single lay-by application when sugarbeet is at the 2-lf stage or greater
Plant Sugarbeet in May	Dual Magnum and/or ethofumesate PRE followed by a split lay-by
Either	Continue to scout fields for late germinating waterhemp in late June and July
Either	Be prepared to rescue with Betamix + ethofumesate, UpBeet + ethofumesate or Betamix + UpBeet (be aware of resistant biotypes)

LITERATURE CITED

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- North Dakota State University Experiment Station and University of Minnesota Crookston Research and Outreach Center

WEED CONTROL FROM ETHOFUMESATE APPLIED POSTEMERGENCE IN SUGARBEET

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SUMMARY

1. Ethofumesate applied postemergence (POST) twice at rates ranging from 12 to 64 fl oz/A suppressed but did not control lambsquarters and redroot pigweed. Ethofumesate POST is not an effective lambsquarters or pigweed herbicide and cannot be considered a second mode of action for control.
2. Ethofumesate alone or ethofumesate plus glyphosate improved waterhemp control compared to glyphosate alone. Control might be related to timing of waterhemp germination and emergence compared to lambsquarters or redroot pigweed.
3. Ethofumesate applied twice at rates ranging from 12 to 64 fl oz/A alone or with glyphosate at 28 fl oz/A caused only minor sugarbeet injury.

INTRODUCTION

Ethofumesate is a time-proven herbicide for grass and small-seeded broadleaf weed control in sugarbeet. Field research from Kansas and Colorado in 1970 indicated 'NC 8438' (ethofumesate) provided greater than 90% green foxtail, foxtail millet, and barnyardgrass control and near 90% redroot pigweed control (Sullivan and Fagala, 1970). Ethofumesate is soil-applied at field use rates up to 7.5 pt/A or applied postemergence up to 12 fl oz/A. Ethofumesate is absorbed by emerging shoots and roots and is translocated to the shoots where it is believed to interfere with lipid biosynthesis (Eshel et al., 1978, Abulnaja et al., 1992). Ethofumesate is sold in the United States using the trade names 'Nortron' by Bayer CropScience, 'Ethotron SC' by UPI, and 'Ethofumesate 4SC' by Willowood USA. Willowood USA is collaborating with the Beet Sugar Development Foundation to develop a new label to expand Ethofumesate 4SC postemergence use rates from 0.8 to 8 pt/A to sugarbeet having greater than two true leaves. Ethofumesate applied in combination with glyphosate may provide an effective second mode of action to complement glyphosate, especially for difficult to control broadleaf weeds in sugarbeet including common lambsquarters, kochia, waterhemp, and common ragweed. However, little is known about postemergence broadleaf weed control from ethofumesate, especially at rates greater than 12 fl oz/A.

Probe experiments were conducted in 2017 to evaluate weed efficacy and sugarbeet safety from single or multiple ethofumesate applications alone or with glyphosate applied postemergence. These probe experiments will serve as a basis for Mrs. Alexa Lystad's MS degree research and will provide recommendations for use of ethofumesate for weed control in sugarbeet grower fields in 2018. The objectives of this research were to determine: a) is ethofumesate safe to sugarbeet; and b) does ethofumesate control weeds?

MATERIALS AND METHODS

Experiments were conducted on indigenous populations of common lambsquarters and redroot pigweed in sugarbeet grower fields near Moorhead and Oslo, Minnesota and Grand Forks, Minto, and Prosper, North Dakota in 2017. Experimental area was prepared with a Kongskilde 's-tine' field cultivator equipped with rolling baskets or with grower cooperator tillage equipment before planting. Experiments were established in fields in 1 or 2 days after grower cooperator planted field to sugarbeet. Herbicide treatments were applied when sugarbeet was at the 2-lf and 6-leaf stage with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 psi to the center four rows of six row plots 30 feet long. Treatments consisted of two applications of ethofumesate at 6, 12, 18, 24, 32 and 64 fl oz/A either alone or with glyphosate at 28 fl oz/A. All treatments of ethofumesate alone contained Destiny HC at 1.5 pt/A. Treatments of ethofumesate plus Roundup PowerMax (glyphosate) contained Destiny HC at 1.5 pt/A plus N-Pak ammonium sulfate at 2.5% v/v. Destiny HC and N-Pak AMS were provided by Winfield United.

Sugarbeet injury and common lambsquarters and/or redroot pigweed control 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 2017.4 software package.

RESULTS

Common lambsquarters control from two postemergence applications of ethofumesate ranged from 0 to 78% across rates and locations (Table 1). Lambsquarters control averaged across ethofumesate rates alone ranged from 27% at Prosper to 49% at Minto. Lambsquarters control generally increased as ethofumesate rate increased from 6 to 64 fl oz/A. However, lambsquarters control was not adequate at any rate within location or at any location for ethofumesate to be considered a stand-alone herbicide for controlling lambsquarters.

Lambsquarters control from two applications of Roundup PowerMax (glyphosate) at 28 fl oz/A was 70% and 90% at Moorhead and Oslo, respectfully. Ethofumesate + glyphosate tended to improve lambsquarters control compared to ethofumesate or glyphosate alone.

Table 1. Common lambsquarters control, 27 to 48 DAT, at Moorhead and Oslo, MN and Grand Forks, Minto, and Prosper, ND, 2017

Treatment[1]	Rate	Application timing[2]	Moorhead MN	Oslo MN	Grand Forks ND	Minto ND	Prosper ND
	fl oz/A		-------------------% control--------------------				
Ethofumesate / Ethofumesate	6 / 6	A/ B	20	20	0	25	13
Ethofumesate / Ethofumesate	12 / 12	A/ B	28	35	28	40	15
Ethofumesate / Ethofumesate	18 / 18	A/ B	35	38	30	48	30
Ethofumesate / Ethofumesate	24 / 24	A/ B	35	40	43	60	33
Ethofumesate / Ethofumesate	32 / 32	A/ B	50	40	53	55	35
Ethofumesate / Ethofumesate	64 / 64	A/ B	53	58	78	63	33
PowerMax[3] / PowerMax	28 / 28	A / B	70	90	100	98	95
Etho + PMax / Etho + PMax	6 + 28/6 + 28	A/ B	78	98	100	90	100
Etho + PMax / Etho + PMax	12 + 28/12 + 28	A/ B	78	94	100	98	100
Etho + PMax / Etho + PMax	18 +28/18 + 28	A/ B	70	100	100	95	100
Etho + PMax / Etho + PMax	24 +28/24 + 28	A/ B	78	100	100	100	100
Etho + PMax / Etho + PMax	32 +28/32 + 28	A/ B	78	99	100	100	100
Etho + PMax / Etho + PMax	64 +28/64 + 28	A/ B	83	99	100	100	100
LSD (0.05)			**10**	**10**	**10**	**12**	**11**

[1]Treatments of Ethofumesate + Roundup PowerMax were applied with N-Pak AMS at 2.5% v/v and Destiny HC at 1.5 pt/A; Ethofumesate was applied with Destiny HC at 1.5 pt/A

[2]Application timing A=2 lf sugarbeet; B= 6 lf sugarbeet

[3]PowerMax or PMax=Roundup PowerMax; Etho=ethofumesate

Redroot pigweed control from ethofumesate was evaluated at Minto and Prosper, ND and Oslo, MN. Pigweed control ranged from 15% to 70% across ethofumesate rates and locations (Table 2). Pigweed control averaged across ethofumesate rates was 34%, 22%, and 41%, at Oslo, Minto, and Prosper, respectfully, or similar to lambsquarters control. As with lambsquarters, ethofumesate applied postemergence is not an effective stand-alone herbicide for controlling redroot pigweed.

Waterhemp control from ethofumesate at Moorhead was a different story than redroot pigweed or lambsquarters. Waterhemp control ranged from 95% from two applications of ethofumesate at 12 fl oz/A to 100% control from two applications at 32 fl oz/A. Waterhemp control tended to increase as the ethofumesate rate increased from 6 to 64 fl oz/A. Waterhemp control from ethofumesate was superior to control from glyphosate.

Differences in broadleaf control from ethofumesate might be related to weed species emergence patterns and application timing. We know the number of growing degree days to trigger lambsquarters and redroot pigweed germination and emergence is much less (lambsquarters) to less (redroot pigweed) than waterhemp (Werle, 2014). Also, since we know that ethofumesate does not translocate from treated leaves to new tissue in emerged vegetation (Eshel, 1978), then it is likely that ethofumesate applied postemergence does little to control emerged weeds but is effective on later flushes once activated by precipitation.

Table 2. Redroot pigweed and waterhemp (Moorhead) control, 30 to 41DAT, at Moorhead and Oslo, MN and Minto, and Prosper, ND, 2017

Treatment[1]	Rate	Application timing[2]	Waterhemp Moorhead MN	Redroot pigweed Oslo MN	Redroot pigweed Minto ND	Redroot pigweed Prosper ND
	fl oz/A		---% control---			
Ethofumesate / Ethofumesate	6 / 6	A/ B	83	25	15	23
Ethofumesate / Ethofumesate	12 / 12	A/ B	95	35	15	28
Ethofumesate / Ethofumesate	18 / 18	A/ B	95	33	18	38
Ethofumesate / Ethofumesate	24 / 24	A/ B	98	28	20	40
Ethofumesate / Ethofumesate	32 / 32	A/ B	100	33	25	45
Ethofumesate / Ethofumesate	64 / 64	A/ B	99	50	40	70
PowerMax[3] / PowerMax	28 / 28		68	93	95	100
Etho + PMax / Etho + PMax	6 + 28/6 + 28	A/ B	95	100	90	100
Etho + PMax / Etho + PMax	12 + 28/12 + 28	A/ B	98	95	95	100
Etho + PMax / Etho + PMax	18 +28/18 + 28	A/ B	100	100	93	100
Etho + PMax / Etho + PMax	24 +28/24 + 28	A/ B	100	100	90	100
Etho + PMax / Etho + PMax	32 +28/32 + 28	A/ B	100	99	94	100
Etho + PMax / Etho + PMax	64 +28/64 + 28	A/ B	100	100	98	100
LSD (0.05)			**8**	**10**	**8**	**15**

[1]Treatments of Ethofumesate + Roundup PowerMax were applied with N-Pak AMS at 2.5% v/v and Destiny HC at 1.5 pt/A; Ethofumesate was applied with Destiny HC at 1.5 pt/A
[2]Application timing A=2 lf sugarbeet; B= 6 lf sugarbeet
[3]PowerMax or PMax=Roundup PowerMax; Etho=ethofumesate

Sugarbeet injury from two applications of ethofumesate alone was negligible across locations in these experiments (Table 3). Sugarbeet injury was negligible even when ethofumesate rate increased from 6 to 64 fl oz/A. Sugarbeet injury from ethofumesate plus glyphosate was similar to injury from either ethofumesate or glyphosate alone.

Table 3. Sugarbeet injury, 27 to 48 DAT, at Moorhead and Oslo, MN and Grand Forks, Minto, and Prosper, ND, 2017

Treatment[1]	Rate	Application timing[2]	Moorhead MN	Oslo MN	Grand Forks ND	Minto ND	Prosper ND
	fl oz/A		---% injury---				
Ethofumesate / Ethofumesate	6 / 6	A/ B	8	3	0	0	3
Ethofumesate / Ethofumesate	12 / 12	A/ B	0	5	0	0	0
Ethofumesate / Ethofumesate	18 / 18	A/ B	3	3	0	0	3
Ethofumesate / Ethofumesate	24 / 24	A/ B	3	3	0	0	3
Ethofumesate / Ethofumesate	32 / 32	A/ B	3	3	3	5	0
Ethofumesate / Ethofumesate	64 / 64	A/ B	3	8	0	0	10
PowerMax / PowerMax	28 / 28	A / B	0	3	0	0	3
Etho + PMax / Etho + PMax	6 + 28/6 + 28	A/ B	3	5	0	0	0
Etho + PMax / Etho + PMax	12 + 28/12 + 28	A/ B	3	3	0	3	0
Etho + PMax / Etho + PMax	18 +28/18 + 28	A/ B	0	3	0	3	3
Etho + PMax / Etho + PMax	24 +28/24 + 28	A/ B	7	5	3	0	8
Etho + PMax / Etho + PMax	32 +28/32 + 28	A/ B	13	5	0	0	0
Etho + PMax / Etho + PMax	64 +28/64 + 28	A/ B	5	10	5	3	8
LSD (0.05)			**NS**	**NS**	**NS**	**NS**	**NS**

[1]Treatments of Ethofumesate + Roundup PowerMax were applied with N-Pak AMS at 2.5% v/v and Destiny HC at 1.5 pt/A; Ethofumesate was applied with Destiny HC at 1.5 pt/A
[2]Application timing A=2 lf sugarbeet; B= 6 lf sugarbeet
[3]PowerMax or PMax=Roundup PowerMax; Etho=ethofumesate

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COMPARING HERBICIDES FOR BROADLEAF WEED CONTROL IN SUGARBEET

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The objective of this study was to evaluate broadleaf weed control from single applications of individual herbicides currently registered for use in Roundup Ready (RR) sugarbeet.

MATERIALS AND METHODS

An experiment was conducted near Hickson, ND in 2017. Fertilizer was spread April 11 and incorporated the same day with a field cultivator equipped with a spring tooth harrow. The trial site was prepared using a Kongskilde 's-tine' field cultivator with rolling baskets on May 13, 2017. Four-foot-wide strips of bioassay species including canola, amaranth, quinoa, and flax were seeded perpendicular to sugarbeet on May 13. Seedex 'Winchester' sugarbeet, treated with NipsIt Suite, Tachigaren at 45g per unit, and Kabina at 7g per unit, were then seeded in 22-inch rows at 60,560 seeds per acre on May 13 with a John Deere 1700XP 6-row planter. Post emergence (POST) treatments were applied June 9. All herbicide 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 35 feet in length.

All sugarbeet injury and weed control 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 for each trial. Data were analyzed with the ANOVA procedure of ARM, version 2017.4 software package.

Table 1. Application Information – Hickson, ND 2017

Date	June 9
Time of Day	12:30 PM
Air Temperature (F)	82
Relative Humidity (%)	42
Wind Velocity (mph)	9
Wind Direction	SE
Soil Temp. (F at 6")	69
Soil Moisture	Fair
Cloud Cover (%)	30
Next Rainfall (amount)	June 11 (0.11")
Sugarbeet Stage	4 leaf
Amaranth (and natural redroot pigweed)	2-6 lf / avg 4 lf
RR canola	2-4 lf/ avg 3 lf (2" tall)
Flax	2-4 inch / avg 3 inch
Quinoa (and natural common lambsquarters)	2-3 inch/ avg 3 inch
Yellow Foxtail	2-3 inch/ avg 3 inch

SUMMARY

UpBeet (triflusulfuron) is the only ALS (group 2) herbicide registered for use in sugarbeet. No sugarbeet injury was observed in this trial from either 0.5 or 1.0 oz/A of UpBeet (Table 2). UpBeet provided the greatest Roundup Ready canola control of all herbicides evaluated. Canola control increased from 73% to 90% at 13 DAT as rate increased from 0.5 to 1.0 oz/A. UpBeet gave 70 to 78% pigweed control and provided some suppression of lambsquarters, flax, and yellow foxtail.

Table 2. Sugarbeet injury and weed control from herbicides at Hickson, ND in 2017.

			16 Jun	-----------------------22 Jun--------------------					
Herbicide	Rate	Rate Unit	Sgbt	Sgbt	rrpw[3]	colq[4]	cano[5]	flax	yefx[6]
			----% inj----		-----------------% cntl------------------				
UpBeet[1]	0.5	oz/A	0	0	70	45	73	45	55
UpBeet[1]	1	oz/A	0	0	78	38	90	65	58
Nortron[1]	12	fl oz/A	5	0	25	25	20	45	0
Nortron[1]	16	fl oz/A	0	0	35	38	25	45	0
Nortron[1]	32	fl oz/A	13	0	50	50	35	48	0
Nortron[1]	64	fl oz/A	3	0	60	58	53	73	0
Stinger[1]	2	fl oz/A	20	-[7]	3	23	0	0	0
Stinger[1]	4	fl oz/A	20	-	3	20	0	0	0
Roundup PowerMax[2]	22	fl oz/A	0	0	99	91	0	100	100
Roundup PowerMax[2]	28	fl oz/A	0	0	100	92	0	100	100
Roundup PowerMax[2]	32	fl oz/A	3	0	100	95	0	100	100
Betamix[1]	12	fl oz/A	25	0	35	40	20	25	0
Betamix[1]	16	fl oz/A	40	10	48	53	18	30	5
Betamix[1]	24	fl oz/A	45	30	60	65	40	35	0
Spin-Aid[1]	12	fl oz/A	20	-	10	53	13	23	0
Spin-Aid[1]	24	fl oz/A	33	-	13	50	23	18	0
Spin-Aid[1]	36	fl oz/A	45	-	23	68	40	35	0
LSD (0.05)			**15**	**-**	**14**	**19**	**11**	**18**	**5**

[1]Herbicide applied with MSO from Loveland at 2 pt/A + AMS at 8.5 lb/100 gal
[2]Herbicide applied with Prefer 90 NIS from West Central at 0.25% v/v + AMS at 8.5 lb/100 gal
[3]rrpw=redroot pigweed + tame amaranth
[4]colq=common lambsquarters + quinoa
[5]cano=Roundup Ready (RR) canola
[6]yefx=yellow foxtail
[7]- = no injury data was recorded due to weed competition. No LSD was calculated due to the missing data.

Nortron (ethofumesate) is the only herbicide found in group 16 and can be applied pre-plant incorporated (PPI), pre-emergence (PRE) or POST in sugarbeet. Current labeling allows for POST application of up to only 12 fl oz/A of Nortron per season. Nortron rates in this trial ranged from 12 to 64 fl oz/A. Very little sugarbeet injury was observed from any rate of Nortron evaluated in this trial at 7 DAT (0 to 13%) and no injury was observed at 13 DAT. At 12 fl oz/A, Nortron provided little control or suppression of any weed species evaluated. Control of all species increased as rate increased, but never above 75%. Nortron did not control yellow foxtail when applied POST at any rate. Though not tested in this trial, data from other trials demonstrates that Nortron improves weed control, including waterhemp or pigweed, when tank-mixed with other herbicides.

Stinger (clopyralid) is the only group 4 (growth regulator) herbicide currently labeled in sugarbeet. Stinger caused 20% sugarbeet leaf curling injury at both 2 and 4 fl oz/A at 7 DAT. This level of injury is generally tolerable early in the season. Stinger provided little to no control of any of the weeds found in this trial. Stinger is an effective herbicide to use in controlling thistle, common ragweed, and giant ragweed, but it has very little if any efficacy against amaranthus species (pigweeds and waterhemp), lambsquarters, or canola. Stinger has no grass activity.

Roundup PowerMax (glyphosate) is a group 9 herbicide and may be applied in Roundup Ready sugarbeet. Roundup is very safe in RR sugarbeet and no notable sugarbeet injury was observed in this trail at any rate tested. Roundup provided the greatest and most consistent control of all species in this trial, with the exception of RR canola. Common lambsquarters was the most difficult weed to control with Roundup, and control varied from 91 to 95% 13 DAT.

Betamix (phenmedipham + desmedipham) is a group 5 (photosynthesis inhibiter) herbicide labeled for use in sugarbeet. Betamix gave moderate sugarbeet injury at all rates tested. Injury ranged from 25 to 45% 7 DAT and 0 to

30% 13 DAT and increased as rate increased. Injury symptoms were leaf burn and some plant height reduction. Betamix provided poor to fair control of pigweed (35 to 60%) and common lambsquarters (40 to 65%), but control improved as rate increased. Weeds were 3 to 4 inches tall at time of application and Betamix is generally considered most effective when applied to cotyledon pigweed or lambsquarters. Betamix provided some suppression of RR canola and flax, but no control of yellow foxtail.

Spin-Aid (phenmedipham) is a group 5 (photosynthesis inhibiter) herbicide labeled for use in sugarbeet. Spin-Aid gave moderate sugarbeet injury at all rates tested. Injury ranged from 20 to 45% 7 DAT and increased as rate increased. Injury symptoms were leaf burn and some plant height reduction. Compared to Betamix (phenmedipham + desmedipham) Spin-Aid (phenmedipham) gave less control of pigweed (10 to 23%) and similar common lambsquarters control (50 to 68%), and control tended to improve as rate increased. Similar to Betamix, Spin-Aid is generally considered most effective when applied to cotyledon pigweed or lambsquarters. Spin-Aid provided some suppression of RR canola and flax, but no control of yellow foxtail.

CONCLUSIONS

Only six herbicide options exist for controlling broadleaf weeds POST in sugarbeet. In this trial, only Roundup PowerMax (glyphosate) gave greater than 90% control of any weeds present. UpBeet at 1 oz/A gave the greatest control of RR canola at 90%. Using UpBeet, Nortron, Stinger, Betamix, or Spin-Aid alone will not provide adequate control of pigweeds, common lambsquarters, or yellow foxtail. Using the appropriate herbicide, however, in conjunction with glyphosate, may improve control of difficult to control weeds, such as waterhemp, lambsquarters, and common ragweed and delay the selection of glyphosate resistant weeds.

EFFICACY OF 'RESCUE' HERBICIDES IN SUGARBEET

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The objective of this trial was to evaluate 'rescue' control of waterhemp using herbicides in sugarbeet. Rescue applications of herbicides are made after an initial herbicide application fails to provide adequate weed control. This is often the situation when glyphosate resistance is first observed in weeds in a field and the initial application of glyphosate failed to provide adequate weed control.

MATERIALS AND METHODS

An experiment was conducted near Lake Lillian, MN in 2017. The seedbed was prepared using a 's-tine' field cultivator. Crystal 'M380' was seeded in 22-inch rows at 60,500 seeds per acre on May 8. Post emergence (POST) treatments were applied June 6 and 20. All herbicide 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 40 feet in length.

A similar experiment was conducted near Moorhead, MN in 2017. The seedbed was prepared using a Kongskilde 's-tine' field cultivator equipped with rolling baskets on May 10. Hilleshog 'HM4022RR' sugarbeet was seeded in 22-inch rows at 60,560 seeds per acre on May 11 with a John Deere 1700XP 6-row planter. POST treatments were applied June 29 and July 7. All herbicide treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

All weed control 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 for each trial. Data were analyzed with the ANOVA procedure of ARM, version 2017.4 software package.

Table 1. Application information for trials at Lake Lillian and Moorhead, MN in 2017.

	Lake Lillian, MN		Moorhead, MN	
	A	**B**	**A**	**B**
Date	June 6	June 20	June 29	July 7
Time of Day	10:00 AM	9:45 AM	10:30 AM	9:30 AM
Air Temperature (F)	78	70	70	75
Relative Humidity (%)		48	69	57
Wind Velocity (mph)	10	11	0	6
Wind Direction	SE	N	NE	E
Soil Temp. (F at 6")		71	69	70
Soil Moisture	Good	Good	Good	Good
Cloud Cover (%)	0	10	95	0
Next Rainfall (amount)	June 11 (1.0")	June 28 (1.0")	July 4	July 18
Sugarbeet Stage	4 leaf	8 leaf	10-12 leaf	14-16 leaf
Waterhemp	4 inch	6 inch	2.5 inch	5 inch
Common Lambsquarters	4 inch	6 inch	4 inch	6 inch

SUMMARY

Lake Lillian

Waterhemp showed an intermediate level of glyphosate resistance. Roundup PowerMax (glyphosate) at 28 fl oz/A fb Roundup PowerMax at 28 fl oz + Ethofumesate 4 SC (ethofumesate) at 6 fl oz + Destiny HSMOC at 1.5 pt/A +

N-Pak AMS at 2.5 % v/v gave only 63% and 50% waterhemp control at 6 and 16 days after application (DAT) B, respectively (Table 2). At 16 DAT, neither UpBeet (triflusulfuron) at 1 oz/A, Ethofumesate 4 SC at 12 fl oz/A, or a combination of both herbicides gave greater than 25% control of waterhemp. The lack of waterhemp control from UpBeet at 1 oz/A suggests the population may also have been resistant to ALS herbicides. No 'rescue' treatment tested gave acceptable control of waterhemp.

Table 2. Waterhemp and common lambsquarters control from rescue herbicides at Lake Lillian, MN in 2017.

Treatment	Rate/A	Appl[1]	June 26 waterhemp	July 6 waterhemp	July 6 lambsquarters
			----------------% control----------------		
UpBeet + MSO	1 oz + 1.5 pt	B	3	18	0
Ethofumesate 4SC + MSO	12 fl oz + 1.5 pt	B	8	25	8
UpBeet + Ethofumesate 4SC + MSO	1 oz + 12 fl oz + 1.5 pt	B	3	20	10
Roundup PowerMax fb	28 fl oz fb	A			
Roundup PowerMax+ Ethofumesate + N-Pak AMS + Destiny HC	28 fl oz + 6 fl oz + 2.5 % v/v + 1.5 pt	B	63	50	100
LSD (0.05)			**11**	**15**	**4**

[1]Appl= Application code listed in Table 1.

Common lambsquarters control was 100% from the treatment containing Roundup PowerMax at 16 DAT (Table 2). UpBeet failed to provide any lambsquarters control. Ethofumesate 4 SC and the combination of UpBeet + Ethofumesate gave 10% or less lambsquarters control.

Moorhead

Sugarbeet injury was generally negligible from herbicides applied. Betamix at 3 pt/A gave 10% to 15% visual injury at 8 and 17 DAT (Table 3) even though sugarbeet were 14 to 16 leaf at application. Injury symptoms were necrotic spots on leaves. All other treatments gave 10% or less injury.

Waterhemp showed an intermediate level of glyphosate resistance. Control from two applications of Roundup PowerMax + Ethofumesate was 78% at 8 days after the second application but only 22% at 17 days after the second application. Treatments containing Betamix provided control ranging from 28% to 40% at 8 DAT but declined to 13% to 36% at 17 DAT. At 17 DAT, those treatments that were a tank-mix of two herbicides tended to give better control than individual herbicides, though no treatment gave greater than 36% control (Betamix + Ethofumesate). No treatment tested provided adequate control of waterhemp.

Common lambsquarters control ranged from 0 to 48% control at 17 DAT from treatments not containing Roundup. Two applications of Roundup PowerMax + Ethofumesate gave 100% common lambsquarters control at 17 DAT.

Table 3. Sugarbeet injury and waterhemp and common lambsquarters control from rescue herbicides at Moorhead, MN in 2017.

Treatment	Rate/A	Appl[1]	July 15 sgbt	July 15 wahe	July 15 colq	July 24 sgbt	July 24 wahe	July 24 colq
			---------------------------------%---------------------------------					
Betamix	3 pt	B	10	28	45	15	13	18
UpBeet	1 oz	B	8	10	3	0	8	0
Ethofumesate 4SC	12 fl oz	B	0	18	15	8	25	33
Betamix + UpBeet	3 pt + 1 oz	B	8	40	45	8	33	20
Betamix + Ethofumesate 4SC	3 pt + 12 fl oz	B	8	23	30	10	36	30
UpBeet + Ethofumesate 4SC	1 oz + 12 fl oz	B	0	10	23	0	30	43

Betamix + UpBeet + Ethofumesate 4SC	3 pt + 1 oz + 12 fl oz	B	8	30	38	5	33	48
Roundup PowerMax+ Ethofumesate fb Roundup PowerMax+ Ethofumesate	28 fl oz + 6 fl oz fb 28 fl oz + 6 fl oz	A B	0	78	100	0	22	100
LSD (0.05)			**NS**	**24**	**24**	**8**	**18**	**12**

CONCLUSIONS

Treatments that did not contain Roundup PowerMax failed to provide adequate control of waterhemp, regardless of herbicide combination or location. Two applications of Roundup PowerMax failed to provide adequate waterhemp control at 16 DAT at either location. Making 'rescue' applications of POST herbicides to control waterhemp that survived a previous POST application will likely result in little to no improvement in waterhemp control in sugarbeet.

Common lambsquarters control was near perfect at both locations from two applications of Roundup PowerMax. All 'rescue' treatments tested failed to provide greater than 48% lambsquarters control at 16 DAT. However, nearly all herbicides evaluated provided some control. This suggests that, if used in conjunction with glyphosate, these herbicides may help delay the onset of glyphosate resistance in common lambsquarters.

SCREENING HERBICIDES FOR CROP SAFETY IN SUGARBEET

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The objective of this trial was to screen pre-emergence and post-emergence herbicides alone and in tank-mixes for sugarbeet crop safety.

MATERIALS AND METHODS

An experiment was conducted near Hickson, ND in 2017. Fertilizer was spread May 2 and incorporated the same day with a field cultivator equipped with a spring tooth harrow. Seedex 'Winchester' sugarbeet, treated with NipsIt Suite, Tachigaren at 45g per unit, and Kabina at 7g per unit was seeded in 22-inch rows at 60,560 seeds per acre on May 3 with a John Deere 1700XP 6-row planter. Pre-emergence (PRE) treatments were applied May 3 immediately after planting. Rain events occurred on May 3, May 7, and May 16 with 0.09, 0.02, and 0.63 inches of rain respectively. Post emergence (POST) treatments were applied June 2. All herbicide 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 35 feet in length. Sugarbeet stand was counted from 10 feet of each of the center two rows on May 26 when sugarbeet were in the cotyledon to 2 leaf stage. Sugarbeet were counted again at harvest. Roundup PowerMax at 32 fl oz/A + Veracity at 3qt/100 gal was applied June 12 and 26 to provide weed control. Escaped weeds were hand pulled throughout the season. Quadris at 16 fl oz/A was broadcast June 24 to control Rhizoctonia root rot. Proline at 5.7 fl oz/A + NIS at 0.125% v/v and AgriTin at 8 fl oz/A + Topsin at 12 fl oz/A were applied July 18 and August 2, respectively, to control Cercospora Leaf Spot. Sugarbeet in the center two rows by 27 feet long were harvested September 7, 2017. Roots were weighed and about 25 lbs of representative roots were collected from each plot and taken to Minn-Dak Farmers Cooperative Quality Lab in Wahpeton, ND for sugar and purity analysis.

All sugarbeet injury 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 for each trial. Data were analyzed with the ANOVA procedure of ARM, version 2017.4 software package.

Table 1. Application Information – Hickson, ND 2017

Date	May 3	June 2
Time of Day	3:00 PM	9:30 PM
Air Temperature (F)	63	86
Relative Humidity (%)	53	45
Wind Velocity (mph)	9	9
Wind Direction	NW	S
Soil Temp. (F at 6")	50	60
Soil Moisture	Good	Good
Cloud Cover (%)	100	5
Next Rainfall (amount)	May 3 (0.09")	June 11 (0.11")
Sugarbeet Stage	PRE	cot-4 leaf/ avg 2 leaf

SUMMARY

Sugarbeet stand counts were taken 7 days before POST treatments were applied. No significant differences were observed among PRE treatments as compared to the untreated check (Table 2). Sugarbeet stands were consistent across the trial. Sugarbeet were counted again on September 7 following defoliation but prior to harvesting. Sugarbeet treated with Satellite Hydrocap (pendamethalin), Cobra (lactofen), or Ultra Blazer (acifluorfen) showed or tended to show decreased stand compared to the untreated check. The treatment of Satellite Hydrocap + Devrinol 2-XT (napropamide) had the fewest sugarbeet of all treatments.

Table 2. Sugarbeet stand and injury ratings from herbicides, Hickson, ND 2017.

Treatment	Rate/A	Timing[1]	May 26 Stand	Sep 7 Stand	Jun 5 Inj[2]	Jun 5 Necr	Jun 5 Chlo	Jun 15 Inj	Jun 22 Inj	Jun 27 Inj
			--- #/100' ---		----------------	----------	-----%-----	----------	----------	----------------
Untreated			188	204	0	0	0	0	5	10
KFD 152-02	1 pt	PRE	184	204	25	0	25	3	15	8
Devrinol 2-XT	4 pt	PRE	194	202	8	1	1	3	13	13
KFD 152-02 + Devrinol 2-XT	1 pt + 4 pt	PRE	201	194	30	0	33	8	15	13
Satellite Hydrocap	1.58 pt	PRE	189	183	25	3	0	33	38	38
Satellite Hydrocap + Devrinol 2-XT	1.58 pt + 4 pt	PRE	199	175	25	3	0	33	40	38
Cobra + COC	10 fl oz + 1.5 pt	POST	198	183	65	70	0	70	80	68
UltraBlazer + COC	1 pt + 1.5 pt	POST	198	186	70	80	0	73	68	65
LSD (0.05)			**NS**	**21**	**13**	**7**	**8**	**9**	**9**	**12**

[1]Timing information displayed in Table 1.
[2]Inj=injury, Necr=necrosis, Chlo=chlorosis

Sugarbeet injury from herbicide treatments varied from 0 to 80% (Table 2). Devrinol 2-XT gave non-significant injury at all visual evaluations. KFD 152-02 (clomazone) applied alone or with Devrinol, showed 25% to 33% chlorosis/bleaching injury early in the season with these injury symptoms diminishing as the season progressed. Satellite Hydrocap applied alone or with Devrinol gave similar sugarbeet injury ranging from 25% to 40% and was generally consistent across evaluations. Variable injury responses were noted from plant to plant from the Satellite application where one plant could be healthy and the adjacent plant showed reduced stature. Cobra or Ultra Blazer applied with crop oil concentrate (COC) gave the greatest amount of injury from 65 to 80%. The injury was leaf necrosis. Both Cobra and Ultra Blazer were applied to small sugarbeet (cot – 4 leaf) and hot weather followed application. These factors may have helped increase injury to such high levels. Injury was generally similar between Cobra and Ultra Blazer, but, as time passed, sugarbeet treated with Ultra Blazer tended to show slightly less injury than those treated with Cobra.

Sugarbeet yield parameters varied by herbicide treatment (Table 3). Root yield was similar from the untreated check, KFD 152-02, Devrinol 2-XT, KFD + Devrinol, Satellite Hydrocap, and Satellite + Devrinol. Sugarbeet treated with Cobra or Ultra Blazer showed 6.2 and 6.8 ton/A reductions in root yield compared to the untreated check. No significant differences were detected in percent sugar, however, there was a tendency from KFD 152-02, Satellite Hydrocap, and Satellite + Devrinol to reduce sugar percentage 0.5% to 0.7% from the untreated check. Purity from these three treatments also tended to be less than the untreated check. Extractable sucrose per acre was greatest from the untreated check. Satellite Hydrocap and Satellite + Devrinol reduced sucrose by about 1,000 lbs/A compared to the check. Cobra and Ultra Blazer reduced extractable sucrose by about 2,000 lbs/A compared to the check.

Table 3. Sugarbeet yield and quality from herbicides, Hickson, ND 2017.

Treatment	Rate/A	Timing[1]	Yield	Sugar	Purity	Ext. Sucrose	Ext. Sucrose
			ton/A	%	%	lb/ton	lb/A
Untreated			31.8	16.7	90.8	288	9149
KFD 152-02	1 pt	PRE	31.3	16.0	89.6	270	8422
Devrinol 2-XT	4 pt	PRE	31.1	16.9	90.3	288	8964
KFD 152-02 + Devrinol 2-XT	1 pt + 4 pt	PRE	30.8	16.9	90.8	291	8967
Satellite Hydrocap	1.58 pt	PRE	30.0	16.2	89.5	273	8185
Satellite Hydrocap + Devrinol 2-XT	1.58 pt + 4 pt	PRE	29.5	16.0	89.8	271	7981
Cobra	10 fl oz	POST	25.2	16.6	90.5	284	7082

+ COC	+ 1.5 pt						
UltraBlazer + COC	1 pt + 1.5 pt	POST	25.0	16.7	90.9	289	7128
LSD (0.05)			**2.9**	**NS**	**NS**	**NS**	**979**

[1]Timing information displayed in Table 1.

CONCLUSIONS

Devrinol 2-XT appears very safe to sugarbeet when applied PRE at 4 pt/A. KFD 152-02 and Satellite Hydrocap tended to impact sugarbeet quality to a greater extent than root yield. Sugarbeet treated with Cobra or Ultra Blazer were severely injured and failed to make a full recovery in time for harvest. Improved crop safety from these products may be seen with reducing rates or delaying application to larger sugarbeet, but additional research should be conducted to test this hypothesis.

TERMINATING FALL-SEEDED COVER CROPS

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SUMMARY

1. Seed cereal rye at no more than 25 pounds per acre.
2. Winter wheat is easier to kill than cereal rye in the spring.
3. Use full herbicides rates. Apply SelectMax at 12 to 16 fl oz/A or PowerMax at 32 to 64 fl oz/A.
4. Apply herbicides as early as possible following cover crop green-up with consideration to the weather forecast 5 to 7 days after application.
5. Herbicides work much slower in early spring and may require 2 to 3-weeks to reach 85% burndown control.
6. Cereal rye stubble may suppress emergence and development of broadleaf weeds including nightshade, lambsquarters, and pigweed.

INTRODUCTION

Sugarbeet farmers have adopted the practice of seeding nurse or cover crops as a companion crop with sugarbeet to reduce stand losses from wind and blowing soils. Spring-seed nurse crops are seeded at sugarbeet planting and are terminated when sugarbeet is at the 4-leaf stage or when small grains are 4 to 5 leaves (tillering). Many farmers have stated they desire to implement cover crops for a longer length of time. That is, seeding cover crops after wheat harvest and prior to sugarbeet planting or after sugarbeet harvest to reduce the chances and amount of blowing soil during the winter and early spring.

Soil health is currently a popular topic in agriculture. The topic is complicated, but the goal essentially is to protect our land resource. Cover crops in sugarbeet production is often discussed since fields are very smooth and contain very little surface crop residue after sugarbeet harvest. In addition, primary and secondary fall tillage is done on fields to be planted to sugarbeet to lessen spring tillage and to conserve moisture in advance of planting next year's sugarbeet crop. Once again, tillage often creates smooth fields that are susceptible to soil erosion, especially in dry and windy conditions.

A probe experiment was initiated in September 2016 with multiple objectives including: a) how effective is spring-applied Roundup PowerMax (glyphosate) or Select Max (clethodim) for killing fall-seeded cover crops; b) when should herbicides be applied to optimize cover crop control and sugarbeet stand establishment; and c) do cover crops provide additional benefits, for example, weed suppression? The goal was to better understand how and when fall-seeded cover crops must be terminated so that sugarbeet can be planted in mid- to late April.

MATERIALS AND METHODS

Prosper, ND. Stubble was chisel plowed following wheat harvest at the Prosper Experiment Station, near Prosper, ND. Secondary tillage was done using a Kongskilde 's-tine' field cultivator with rolling baskets on September 6, 2017. Experiment was a split plot design with 4 replications. The main (whole) plot was fall seeded cover crop; the subplot was herbicide, herbicide rate, and timing of herbicide application.

Winter wheat at 60 lb/A, cereal rye at 50 lb/A, and a mixture of oat at 40 lb/A and tillage radish at 5 lb/A were spread by hand across respective whole plots in each replication and shallow tilled to incorporate seeds into soil on September 6, 2017. One main plot was left with no cover crop.

Select Max at 6 fl oz/A + 1.5 pt/A methylated seed oil (MSO) and Roundup PowerMax at 28 fl oz/A + Prefer 90 non-ionic surfactant (NIS) at 0.25% v/v with ammonium sulfate (N-Pak-AMS) at 2.5% v/v were applied as treatments on April 17, April 21, and April 29, 2017 when winter wheat was 5, 5, and 7-inches, respectfully, and cereal rye was 8, 9, and 10 inches, respectfully (Table 1). All herbicide treatments were applied with a bicycle sprayer (without the customary hood) in 17 gpa spray solution through 11002 Turbo TeeJet nozzles pressurized with CO_2 at 40 psi across plots. Percent visual control or burndown of winter wheat and cereal rye was evaluated on April 29, May 5, May 12, and May 23, 2017.

Table 1. Application Information – Prosper, ND 2017

Date	April 17	April 21	April 29
Time of Day	3:00 PM	3:00 PM	4:00 PM
Air Temperature (F)	49	62	58
Relative Humidity (%)	33	38	16
Wind Velocity (mph)	4	2	6
Wind Direction	NW	W	NE
Soil Temp. (F at 6")	54	56	46
Soil Moisture	Good	Good	Good
Cloud Cover (%)	80	10	30
Winter Wheat	5 inch	5 inch	7 inch
Cereal Rye	8 inch	9 inch	10 inch

'SV36272RR' sugarbeet, treated with NipsIt Suite, Tachigaren at 45g per unit, and Kabina at 7g per unit, was seeded in 22-inch rows at 60,560 seeds per acre on May 26, 2017. PowerMax at 32 fl oz per acre + ClassAct NG at 2.5% v/v was applied on June 19 and July 10, 2017 to control weed escapes in the trial.

Renville, MN. Cereal rye at 100 lb/A was seeded into a preharvest sugarbeet field on September 12, 2016. Rye was harrowed into the soil following seeding using a field cultivator. Roundup PowerMax at 22, 32, and 64 fl oz/A plus Class Act NG at 2.5% v/v or SelectMax at 6 fl oz/A plus Class Act NG at 2.5% v/v was applied to the center 7.3 ft of an 11 ft plot by 30 feet long on April 7, 2017. Herbicide was applied with a bicycle sprayer at 17 GPA through TeeJet 8002XR nozzles at 40 psi.

Evaluations were a visual assessment of cereal rye control (visual reduction in ground cover) on April 17, April 21 and April 28, 2017.

Data were analyzed with the ANOVA procedure of ARM, version 2017.4 software package.

RESULTS AND DISCUSSION

Cover Crop Establishment and Overwintering at Prosper. A visual assessment of cover crop establishment was collected on October 27, 2016. In general, cover crop emergence and percent visual ground cover was very good, perhaps exceeding expectations (Table 2). Favorable moisture conditions and warm temperatures in the fall of 2016 promoted cover crop growth. Cereal rye growth was most uniform while winter wheat was the least uniform. Tillage radish emerged but were small, ranging from 0.5 to 1 inch in diameter and 2 to 4 inches long. Ground cover in the no-cover crop main plot was a uniform cover of volunteer spring wheat.

Table 2. Percent visual ground cover and range of observations across replications, October 27, 2016 at Prosper, ND

	Ground Cover	Range of Ground Cover Observations
Cover Crop	%	%
Winter Wheat	60	40-70
Cereal Rye	85	80-90
Oat and Tillage Radish	68	50-80
No Cover Crop[1]	38	30-40

[1]Block contained volunteer wheat from previous crop

Cover crop establishment was evaluated April 6 and April 13, 2017 following snow melt. On April 6, the cereal rye whole plots were greening up, but there was very little visual evidence of living winter wheat. Spring green-up and early season growth changed quickly in one week. On April 13 the number of green cereal rye or winter wheat plants per meter square were counted and a visual assessment of green-up was taken in $1m^2$ quadrats at three evenly spaced points within the cover crop whole plot. Cereal rye ground cover and uniformity were greater than winter wheat which may have suffered some winter-kill damage (Table 3). However, the number of rye or winter wheat plants per m^2 were similar. This may be attributed to the aggressive behavior of cereal rye which was well tillered on April 13 and was in general, much more robust than winter wheat.

Seeding rates were determined from the literature and through personal communication. In both cases, there was a wide range of opinions regarding seeding rates. Cereal rye seeding rate of 50 lb/A was much too great as the rye whole plots resembled sod.

Cereal Rye and Winter Wheat Control at Prosper. Percent visual control or burndown was collected April 29 (data not presented), May 5, May 12, and May 23, 2017. In general, winter wheat burndown was faster than cereal rye. Roundup PowerMax at 28 fl oz/A applied on April 17 or April 21 controlled 70% or 75% winter wheat on May 5 or 18 or 14 DAT (days after treatment), respectfully. PowerMax gave only 45% and 25% cereal rye control (Table 4). Winter wheat control from PowerMax ranged from 83 to 98% control by May 12 or 17 to 25 DAT. A minimum of 90% burndown control of cereal rye did not occur until May 23 or 32 to 28 DAT and following PowerMax application on April 21 or April 25. Roundup PowerMax provided greater overall cereal rye and winter wheat control and speed of kill than SelectMax. However, herbicide rate for both Roundup PowerMax and SelectMax probably were not sufficient, especially for early spring application. These results support the recommendation of full herbicide rates, including PowerMax at 32 to 43 fl oz/A and SelectMax at 12 to 16 fl oz/A. The use of appropriate adjuvants will also accentuate herbicide efficacy.

Cereal rye early-season growth and development was very rapid. Herbicide burndown application should be timed as early as possible or immediately after green-up in early spring. However, application timing is a compromise between growth and development of target species and environmental conditions. For example, the April 17 application was followed by wintry weather including 2 to 3 inches of snow and low temperatures. The cereal rye and winter wheat control data suggests herbicides and cover crop efficacy including speed of kill were influenced by environmental conditions.

Table 4. Percent visual cereal rye and winter wheat control, across herbicide, application timing, and evaluation date, Prosper, ND

		May 5		May 12		May 23	
		c rye	w wheat	c rye	w wheat	c rye	w wheat
Herbicide[1]	Appl Date	%	%	%	%	%	%
PowerMax	April 17	55 cd	70 ab	65 c	83 b	75 c	85 b
Select Max	April 17	20 ef	45 d	5 f	60 c	0 g	20 f
PowerMax	April 21	60 bc	75 a	83 b	98 a	100 a	99 a
Select Max	April 21	5 g	25 e	25 e	50 d	0 g	55 d
PowerMax	April 25	20 ef	30 e	70 c	88 b	98 a	100 a
Select Max	April 25	0 g	10 fg	20 e	25 e	20 f	45 e
LSD (0.05)		**10**		**7**		**7**	

[1]Roundup PowerMax at 28 fl oz/A + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v; Select Max at 6 fl oz/A + Noble MSO at 1.5 pt/A

Cereal Rye Control at Renville. Cereal rye control (burndown) was dependent on Roundup PowerMax rate and number of days between application and evaluation. Roundup PowerMax at 64 fl oz/A gave 95% cereal rye control 21 DAT (Table 5). Cereal rye control from PowerMax at 32 fl oz/A was similar to control from PowerMax at 64 fl oz/A on April 21 and April 28 or 14 and 21 DAT. However, numbers of days to achieve similar numeric control from PowerMax at 64 fl oz/A was approximately 7 days faster than from PowerMax at 32 fl oz/A. PowerMax at 64 fl oz/A provided greater rye burndown control than PowerMax at 22 fl oz/A. Cereal rye control from SelectMax at 6 fl oz/A was less than control from PowerMax, regardless of rate.

Table 5. Percent visual cereal rye control, across herbicide, herbicide rate, and evaluation date, Renville, MN

Herbicide[1]	Herbicide Rate	April 17	April 21	April 28
	fl oz/A	----------------------------	% Control	----------------------------
PowerMax	22	41 b	61 b	76 b
PowerMax	32	41 b	73 a	85 ab
PowerMax	64	69 a	86 a	95 a
SelectMax	6	10 c	17 c	31 c
LSD (0.05)		**16**	**12**	**10**

[1]Roundup PowerMax at 28 fl oz/A + Class Act NG at 2.5% v/v; SelectMax at 6 fl oz/A + Class Act NG at 2.5% v/v

Weed Suppression at Prosper. There is some evidence suggesting cover crop stubble suppresses germination and emergence of broadleaf weeds. Percent weed suppression across cover crop and burndown herbicide combination was collected visually on June 6 and June 12 and was collected using stand counts per unit area on June 12. Cereal rye stubble appeared to suppress emergence and growth of hairy nightshade, lambsquarters, and pigweed compared to winter wheat stubble or the no-cover crop whole plots, but weed suppression was confounded by incomplete cover crop burndown control in some treatments. Therefore, the data is not presented. Hairy nightshade, lambsquarters, and pigweed suppression in whole plots seeded with winter wheat was similar to broadleaf weed suppression in the no-cover crop whole plots. However, there was a two-fold numeric increase in weed number in the no-cover crop whole plot compared with the winter wheat whole plot. Both visual and stand count data collected June 6 and 12 suggest that cereal rye stubble suppresses broadleaf weeds even after rye was killed with April applications of Roundup PowerMax.

LIBERTY APPLIED WITH ADJUVANTS IN LIBERTYLINK SOYBEAN

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BACKGROUND

Liberty (glufosinate) is a broad spectrum grass and broadleaf control herbicide used in combination with LibertyLink soybean. Liberty is applied postemergence at 0.53 to 0.65 lb ai/a (29 to 36 fl oz/A) between soybean emergence and pre bloom when weeds are up to three inches tall. A repeat Liberty application can be made at up to 0.53 lb ai/a. Liberty is applied with ammonium sulfate (AMS) at 3 lb/a in at least 15 gal/a water using nozzles and pressure to produce a medium sized droplet. Using Liberty in LibertyLink crops offers growers herbicide diversity since it has a unique site of action (SOA 10) and controls glyphosate-resistant weeds including kochia, common ragweed, and waterhemp.

Ammonium sulfate should always be added when using Liberty herbicide. Ammonium sulfate enhances Liberty absorption and movement through the leaf cuticle. Calcium magnesium, sodium, and potassium have been reported to reduce the efficacy of weak acid herbicides like Liberty. Ammonium sulfate counteracts the antagonistic effects of hard water salts. As water in the spray droplet evaporates, sulfate from AMS binds with antagonistic salts which prevents them from binding with Liberty. In addition, ammonium from AMS binds with Liberty resulting in greater uptake into the plant and greater resultant weed control.

There are many products, including liquid-based products, that improve herbicide uptake and deactivate antagonistic hard water salts. Liquid-based products tend to be easier to handle and have given consistent performance in trials when used with glyphosate. ET-4000 is an acidic ammonium sulfate replacement. ET-4000 is a sulfuric acid based product that turns to a sulfate when in the presence of water. The objective of this study was to evaluate common lambsquarters and waterhemp control from liquid-based AMS replacements applied with Liberty.

MATERIALS AND METHODS

An experiment was conducted near Moorhead, MN in 2017. The trial site was prepared for planting using a Kongskilde s-tine field cultivator on May 10, 2017. Peterson Farm 'L07-16N' LibertyLink soybean was planted in 22-inch rows at 160,000 seeds per acre on May 11 with a John Deere 1700XP 6-row planter. Postemergence (POST) treatments were applied June 19. All herbicide treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 30 feet in length. Soybean injury and common lambsquarters and waterhemp control were evaluated June 29 and July 11, 2017.

Table 1. Application 'A' Information – Moorhead, MN 2017

Date	June 19
Time of Day	9:30 AM
Air Temperature (F)	65
Relative Humidity (%)	54
Wind Velocity (mph)	4
Wind Direction	N
Soil Temp. (F at 6")	62
Soil Moisture	Good
Cloud Cover (%)	80
Next Rainfall (amount)	June 28 (0.3 inches)
Soybean Stage	3-trifoliolate
Common lambsquarters	6-in tall
Waterhemp	2-in tall

All soybean injury and weed control 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 for each trial. Data were analyzed with the ANOVA procedure of ARM, version 2017.4, software package.

RESULTS

Common lambsquarters tends to germinate in late April and early May in western Minnesota and eastern North Dakota. There was a very dense common lambsquarters population at this location even though the first flush was controlled by tillage prior to planting. Waterhemp generally emerges in mid to late May and continues to emerge following precipitation events throughout the summer. Waterhemp density was low to moderate at this location and was clearly impacted by lambsquarters competition and from fewer than normal precipitation events in June and July at Moorhead in 2017.

There was no visual soybean injury from Liberty across adjuvants (Table 2). Lambsquarters was the best indicator species of weed control in this experiment. Lambsquarters control ranged from 84 to 93% across treatments at 10 DAT and from 60 to 74% across treatments at 22 DAT. Applying Moccasin (a soil residual herbicide) with Liberty + AMS or Liberty+ET-4000 gave less lambsquarters control at 10 DAT compared to Liberty+AMS. Liberty+ET-4000+Moccasin gave similar lambsquarters control at 22 DAT compared to Liberty+AMS.

Common lambsquarters control was similar among treatments containing dry or liquid AMS adjuvants with Liberty including ET-4000. No significant differences in lambsquarters control were observed at 10 or 22 DAT from any Liberty alone+adjuvant treatments.

Moccasin was applied with Liberty to provide residual lambsquarters and waterhemp control. However, greater than 0.5 inches of precipitation is recommended to sufficiently activate Moccasin and this precipitation did not occur until August 2, or 44 days after application. Lambsquarters control from Liberty plus Moccasin, 10 DAT was less than from Liberty+AMS, suggesting the tank-mix with Moccasin may have antagonized broadleaf control.

Liberty alone with dry AMS, liquid AMS, or ET-4000, or Liberty tank-mixed with Moccasin provided perfect or near perfect waterhemp control in this experiment.

Table 2. Soybean injury and weed control from adjuvants with Liberty at Moorhead, MN in 2017.

			----------June 29---------			---------July 11---------		
Treatment	Rate	Appl[1]	soyb[2]	colq	wahe	soyb	colq	wahe
	fl oz/A + adjuvant		%inj	%cntl	%cntl	%inj	%cntl	%cntl
Liberty+dry AMS[3]	29 + 3 lb/a	A	0	92	100	0	69	98
Liberty + N-Pak AMS	29 + 5% v/v	A	0	89	100	0	70	100
Liberty + ET-4000	29+ 1.5% v/v	A	0	88	100	0	68	100
Liberty + ET-4000	29 + 3% v/v	A	0	91	98	0	74	100
Liberty + Moccasin[4] + N-Pak AMS	29 + 21 + 5% v/v	A	0	84	100	0	60	100
Liberty + Moccasin + ET-4000	29 + 21 + 1.5% v/v	A	0	85	95	0	70	98
LSD (0.05)			**NS**	**4**	**5**	**NS**	**9**	**NS**

[1]Appl refers to application timing and corresponding information in Table 1.
[2]soyb=soybean; colq=common lambsquarters; wahe=waterhemp
[3]Indicates addition of ammonium sulfate (AMS) at 3 lb/A. N-Pak AMS used at 5 %v/v and provided by Winfield. ET-4000 used at 1.5% v/v and provided by MK Ag Service
[4]S-metolachlor by UPI

CONCLUSIONS

Dry AMS with Liberty provided fair to good lambsquarters control and excellent waterhemp control. N-Pak AMS or ET-4000 with Liberty generally provided similar lambsquarters control. ET-4000 at 3% v/v with Liberty tended to improve lambsquarters control compared to ET-4000 at 1.5% v/v with Liberty. Lambsquarters control from Moccasin plus Liberty, regardless of adjuvant type, was less than from Liberty+adjuvant, especially 10 DAT. The addition of Moccasin did not provide residual control. Waterhemp control from Liberty was similar among the adjuvants and tank mixes tested.