Gold Section: Sugarbeet Weed Control Page

A STRATEGY FOR MANAGING WATERHEMP IN SUGARBEET

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Summary

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

Introduction

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

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

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

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

Materials and Methods

Experiments were conducted on natural populations of waterhemp near Herman and Moorhead, Minnesota in 2015. Plot area was worked by the cooperating farmer with a John Deere field cultivator equipped with rolling baskets on June 4, 2015 at Herman and with a Kongskilde s-tine field cultivator on April 30, 2015, at Moorhead. 'SesVanderhave 36271RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on June 4 and April 30, 2015, respectively. Herbicide treatments were applied at Herman June 4, June 18, and July 7, 2015 and at Moorhead May 1, June 2, and June 19, 2015. All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 30 feet in length in fields with moderate to heavy infestations of glyphosate-resistant waterhemp. Ammonium sulfate (AMS) in all treatments was 'N-Pak' AMS, a liquid formulation from Winfield Solutions. Non-ionic surfactant (NIS) was 'Prefer 90', a product from West Central, Inc.

Sugarbeet injury was evaluated July 7, July 21, and July 31 at Herman, MN, and June 11 and July 1, 2015 at Moorhead, MN. Waterhemp control was evaluated July 7, July 21, and July 31, 2015 at Herman, MN, and June 11, July 1, and August 25, 2015 at Moorhead, MN. Lambsquarters control was evaluated July 21, 2015 at Herman, MN and August 25, 2015 at Moorhead, MN. All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package and with the ANOVA procedure as a split-plot analysis to determine interaction effects using SAS Data Management version SAS 9.3 software package.

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

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

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

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

Results and Discussion

Sugarbeet experiments were conducted at multiple locations in 2014 and 2015 to evaluate waterhemp control. Waterhemp control ranged from 34% to 66% across experiments and years from either two or three POST applications of Roundup PowerMax (Table 3). In all experiments, Roundup PowerMax was applied with NIS and AMS. The data shown in Table 3 indicate the presence of glyphosate-resistant waterhemp biotypes that were not controlled with multiple full-rate applications of glyphosate. These data are consistent with results from experiments conducted from 2010 through 2013 and conclude that making repeat applications of glyphosate alone is not an effective strategy to control waterhemp in sugarbeet fields.

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

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

[1]Roundup PowerMax at 28 followed by (fb) 28 fb 22 fl oz/A or Roundup PowerMax at 28 fb 28 fl oz/A; + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v
[2]Visual percent waterhemp control at preharvest evaluation
[3]- indicates experiment was not conducted at that location

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

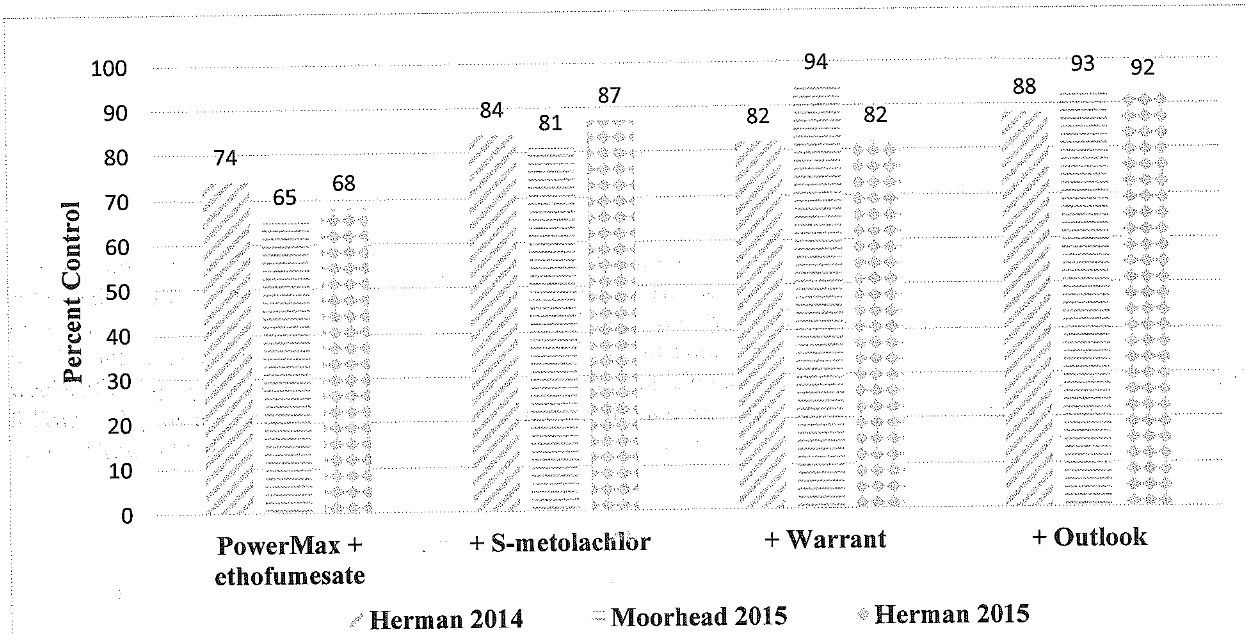

Figure 1. Waterhemp control from glyphosate plus ethofumesate and lay-by herbicides at different locations in 2014 and 2015.

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

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

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

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

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

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

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

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

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

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

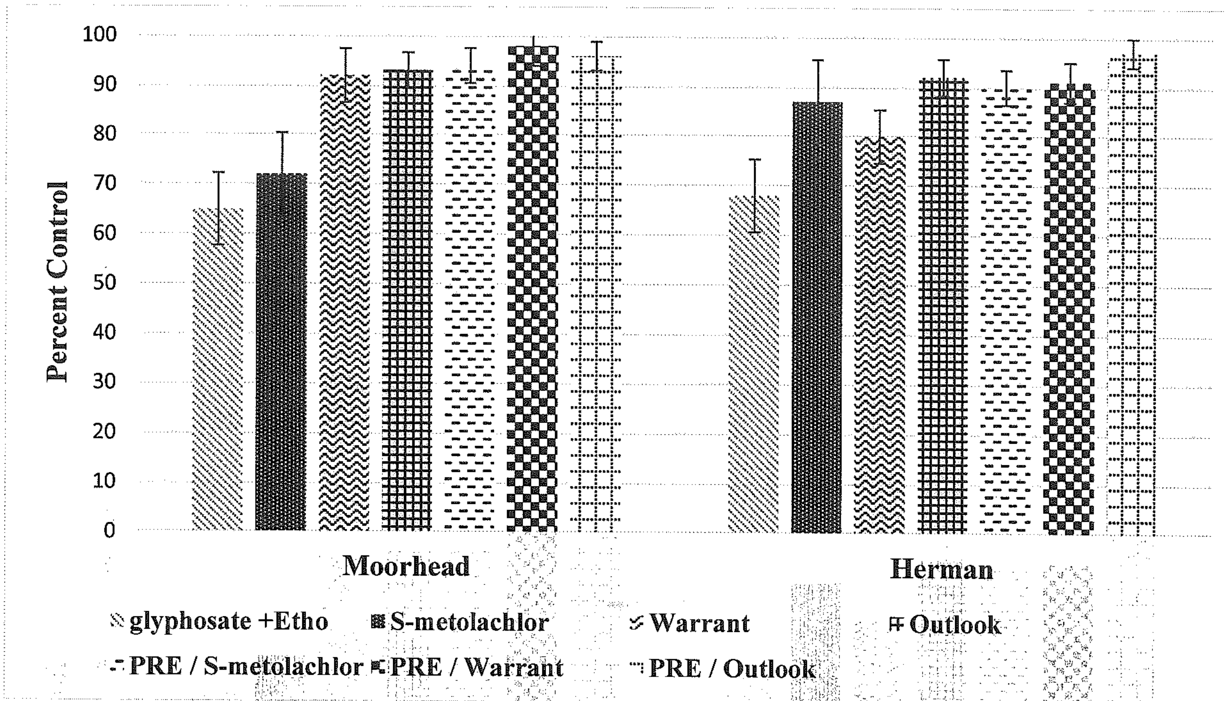

Figure 2. Waterhemp control[1] from lay-by herbicides[2] and PRE S-metolachlor followed by lay-by herbicides, at Herman, MN and Moorhead, MN in 2015.

[1]Standard deviation for herbicide comparisons by location

[2]Etho = ethofumesate

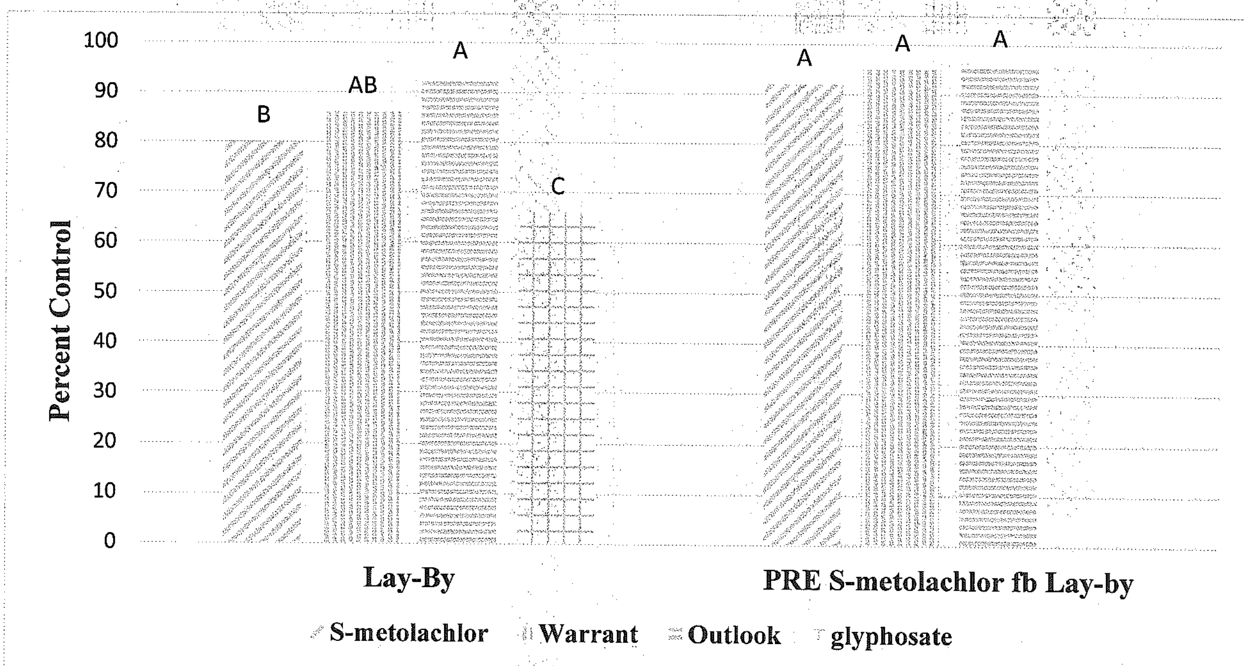

Figure 3. Waterhemp control from lay-by herbicides and PRE S-metolachlor followed by lay-by herbicides, averaged across Herman, MN and Moorhead, MN in 2015.

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

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

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

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

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

Future Research

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

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ESTIMATING TIME OF WATERHEMP EMERGENCE USING A GROWING DEGREE DAY CALCULATOR

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Summary

1. Waterhemp germination and emergence occurs the end of May in sugarbeet growing regions in eastern North Dakota and Minnesota.
2. Positive verification and reporting of waterhemp germination and emergence in 2016 will enable adjustment of the 'Tbase' component of the model and improve accuracy of the forecast model

Introduction

Waterhemp is different from redroot pigweed in that it germinates and emerges later in the spring. It also emerges over a prolonged period of time (8 to 10 weeks) as compared to redroot pigweed. Thus, lay-by application of residual herbicides (herbicide application after sugarbeet have emerged but before waterhemp emergence) is a good weed management strategy for providing season-long control. Metolachlor, (Dual Magnum, Cinch and generics), Warrant and Outlook are labeled for waterhemp control lay-by when sugarbeet growth stage ranges from 2 to 8 leaves.

Sugarbeet rarely germinate and emerge uniformly. Thus, farmers must delay lay-by herbicide application to ensure sugarbeet stand is complete and sugarbeet across the field are at minimum in the 2-leaf stage before application. To achieve maximum control, lay-by herbicides must be rainfall activated prior to weed emergence since these herbicides do not control emerged weeds. This means farmers need to be concerned about germinating and emerging weeds, especially waterhemp. In many respects, lay-by application is a compromise between sugarbeet growth stage, activation of residual herbicide, and the germination and emergence of weeds. The idea for waterhemp control with lay-by herbicides is to position the application to maximize the longevity of the soil-applied herbicide in order to combat waterhemp throughout the duration of the growing season.

Growing degree days (GDD) have many applications in crop management. Accumulated GDD, calculated by summing GDDs for each day during a period, are useful in tracking the development of several important crops and insect pests. One of the original uses of GDD was characterization of corn development and classifying corn hybrid maturities. Corn has a base temperature of 50°F and each corn hybrid has a certain GDD requirement to reach maturity. Those grown in the central Corn Belt require anywhere from 2100 to 3200 GDD depending on the hybrid and critical time points such as tasseling, silk emergence and kernel blistering. Relative maturity can be measured by GGD.

GDDs have been used to classify weeds to simplify scouting (Iowa State University IPM-64). Annual weeds were clustered into five groups based on GDD accumulation ranging from less than150 (winter annuals) to grasses and broadleaves that germinated and emerged at greater than 350 accumulated GDD (base 48). By tracking GDDs, it may be possible to estimate waterhemp germination and emergence in order to time application of lay-by residual herbicides in sugarbeet. The objective of this probe experiment was to determine if waterhemp GDD accumulation could forecast waterhemp germination and emergence and be used as a tool to time residual herbicide application in sugarbeet.

Materials and Methods

Daily maximum and minimum temperatures were collected from NDAWN (North Dakota Agricultural Weather Network) or NOAA (National Oceanic and Atmospheric Administration) weather stations located near Prosper and Wahpeton, North Dakota and Moorhead, Sabin, Morris, Montevideo and Litchfield, Minnesota. GDDs were calculated by determining the mean daily temperature and subtracting this value from the base temperature needed for germination and emergence of waterhemp. Based upon the information developed by researchers at Iowa State University (1), the base temperature selected was '48°F' and accumulated GDDs was 350.

The GDD accumulation for one day for waterhemp was represented by the equation:

GDD = (Tmax +Tmin)/2 - Tbase

where:
Tmax is maximum daily air temperature
Tmin is the minimum daily air temperature
Tbase is the base temperature for waterhemp, '48' based on research conducted at Iowa State University.

Calendar date when accumulated GDDs, calculated by summing GDDs for each day from January 1, 2015, totaled 350 would be first date for waterhemp emergence. Farmers would need to anticipate precipitation events and apply lay-by herbicides at least five to seven days in advance of calendar date to ensure herbicide was activated before the calendar date for waterhemp emergence.

Results

Waterhemp growing degree day accumulation (calculated using NDAWN and NOAA stations maximum and minimum daily temperature data) and resultant calendar date to accumulate approximately 350 GDDs are presented in Table. Data indicated only a six day difference in calendar day to accumulate 350 GDDs from stations/cities 200 miles apart. Data also indicates 350 GDD accumulation generally occurred by late May.

"The second half of June" was the common reply during winter grower meetings when asked when waterhemp would germinate and emerge in sugarbeet in central and west central Minnesota in 2015. This calendar date was based on estimates of waterhemp emergence from studies conducted in Iowa fields and 2014 experiments near Herman and Moorhead, MN. **The predicted date of waterhemp germination and emergence was clearly inaccurate!**

The first telephone calls in 2015 about possible waterhemp emergence occurred in early May. However, the 'callers' often were not comfortable with positive waterhemp identification since waterhemp is very similar to redroot pigweed, powell pigweed or smooth pigweed during the early vegetative stage. The data in Table suggest there is a possibility those early observations in southern Minnesota were indeed waterhemp.

Table ~~1~~. Growing Degree Days (GDDs) accumulated to predict the calendar date of waterhemp emergence at 7 locations in 2015.

Location	Calendar Date	Accumulated GDDs
Prosper, ND	June 2	358
Moorhead, MN	May 28	353
Sabin, MN	May 28	354
Wahpeton, ND	May 31	349
Morris, MN	May 29	359
Litchfield, MN	June 3	348
Montevideo, MN	May 29	357

Discussion

2014 was a late spring for sugarbeet growers and researchers alike. The majority of our research locations were planted after May 15th and into freshly tilled fields. In retrospect, there may have been very small waterhemp germinating and emerging in experimental locations at planting at the Moorhead and Herman, MN locations. We typically till the experimental area prior to planting to ensure emerged or emerging weeds do not confound results. Thus, waterhemp would reinitiate the germination and emergence process at planting, partially explaining a predicted waterhemp emergence date of 'after June 15.'

Record keeping on waterhemp GDD accumulation in 2015 combined with greater knowledge of the biology of waterhemp supports the revised hypothesis, that waterhemp germinates and emerges end of May in sugarbeet growing regions in Minnesota and North Dakota. This working hypothesis will be tested for confirmation in 2016. Positive identification of waterhemp at the cotyledon to two leaf stage is critical to complete and verify the model. Second, the observation much occur in fields near climate collection instrumentation.

Future Research

Waterhemp germination and emergence will be tracked at several locations in 2016 to improve waterhemp forecast tracking and model development. Several agriculturalists and consultants shall assist in positive waterhemp identification and documentation of the first calendar date associated with the sighting. Observations shall occur at multiple locations in sugarbeet growing regions to verify the model.

Leadership at sugarbeet cooperatives have committed to utilizing resources to develop an electronic application to track GDD accumulation. The idea is for these estimates to be tracked and available for access on a smart phone application. We believe a forecast of waterhemp germination and emergence using a model is an obtainable goal and will assist farmers with management decisions for waterhemp control in sugarbeet.

Literature Cited

1. Iowa State University Extension and Outreach, "Weed Emergence Sequences: Knowledge to guide scouting and control" (2000). Agriculture and Environment Extension Publications. Book 214.

SPRING-SEEDED CEREALS AS COVER CROPS IN SUGARBEET

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Summary

1. Spring-seeded oat cover crop tolerates soil-applied S-metolachlor and ethofumesate better than barley and wheat.
2. S-metolachlor at 0.5 and 1 pt/A is safe on oat but S-metolachlor at 1 pt/A can greatly reduce barley and wheat ground cover. Ethofumesate at 1 pt/A may be applied only when oat is used as a spring-seeded cover crop.
3. Terminate wheat cover crop no later than the sugarbeet 6-leaf stage to maximize sugarbeet yield and extractable sucrose.
4. Wheat cover crop suppresses broadleaf weed emergence compared to no cover crop. Preliminary research suggests seeding rate from 0.75 to 1.5 bu/A would maximize the benefit.

Introduction

Farmers use spring-seed cover crops as a companion crop in sugarbeet for various reasons. Cover crops protect sugarbeet from high winds or damage from blowing soil. While the immediate benefit is to protect sugarbeet stands, cover crops reduce soil erosion which benefits soil health and is a best management practice that improves the sustainability of agriculture. There are other benefits. Farmers who produce sugarbeet for Southern Minnesota Beet Sugar Coop seed spring-seeded cereals as cover crops in exchange for phosphorus credits in cooperation with the Minnesota Pollution Control Agency, ultimately contributing to processing capacity.

The Farmer has other management considerations when he/she elects to seed cover crops as a component in the sugarbeet production system. For example, soil-applied herbicides, used for waterhemp control, may injure certain cover species and negatively impact cover crop stand. Second, timing of cover crop termination is important since actively growing cover crops may reflect solar energy away from sugarbeet and negatively impact extractable sucrose (lb/A). Finally, there are indications that cover crops suppress germination and emergence of broadleaf weeds, at least early in the season.

Use of spring-seeded cover crops is important in eastern North Dakota and Minnesota. Farmers that participated in the annual growers survey reported spring-seeded cover crops usage on 49% of the sugarbeet acres in 2015 (Table 1) or a 5% increase from 2014 survey results. The goal of this article is to share information about cover crops so that Farmers may realize a positive first experience from cover crop usage. The following report is a product of three years' experience with cover crops and is designed to address questions and technical challenges so that use of cover crops in sugarbeet maintains or increases its importance in 2016.

This report includes: a) a summary of three years' experience evaluating the impact of soil-applied herbicides on spring-seeded cereal cover crops; b) the effect of timing of cover crop removal on pounds per acre extractable sugar; and c) the effect of increasing cover crop density on suppression of broadleaf weeds in sugarbeet.

Table 1. Percent of sugarbeet acres seeded with various cover crops in 2015, by county.

County	No. of responses	Acres planted	Barley	Oat	Wheat	Rye	Other	No Cover Crops
			-----------------------% of acres planted-----------------------					
Cass	3	1,434	28	-	-	-	-	72
Chippewa[1]	14	7,976	6	59	15	-	-	20
Clay[2]	6	3,148	32	-	-	-	-	68
Grand Forks	4	5,143	40	-	-	-	-	60
Kittson	3	1,820	7	-	-	-	-	93
Marshall	2	1,425	-	-	-	-	-	100
Norman	3	3,404	75	-	-	-	-	25
Pembina	3	2,159	-	-	54	-	-	56
Polk[3]	14	6,486	24	-	-	-	-	76
Renville[4]	15	9,246	-	17	40	-	-	43
Richland	5	6,095	43	-	37	4	-	16
Traverse[5]	5	4,605	33	-	18	-	-	49
Walsh	4	1,985	-	-	20	-	-	80
Wilkin	9	3,850	53	-	3	-	-	44
Total	90	58,776	25	10	15	<1	-	51

[1]Includes Kandiyohi, Swift and Pope Counties
[2]Includes Becker County
[3]Includes Pennington County
[4]Includes Redwood and Yellow Medicine Counties
[5]Includes Grant County

Materials and Methods

Impact of soil-applied herbicides on spring-seeded cereal cover crops

Experiments were conducted near Foxhome, Minnesota in 2015. The experimental area was prepared using an Alloway Seedbetter equipped with rolling baskets on April 30, 2015. Experiment was a randomized complete block design (RCBD) with four replications in a split-plot arrangement with the whole plot being cover crop species and the subplot being herbicide. Each herbicide rate for a given herbicide was treated as a separate subplot. Barley, oat and wheat were broadcast applied at 1 bu/A utilizing an Earthway 3400 handheld spreader (Earthway Products Inc., Bristol, IN) before being incorporated using a Melroe spring-tooth drag. 'Crystal 981RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre the same day.

Preemergence herbicides (sub-plot treatments) were applied with a bicycle sprayer at 15 gallons per acre (gpa) spray solution through 8002 flat fan nozzles pressurized with CO_2 at 40 pounds per square inch (psi). Herbicides were applied to the center four rows of six row plots 25 feet in length.
Glyphosate at 32 fl oz/A was applied on June 9th and June 30th for weed control. Each application of glyphosate included ammonium sulfate at 8.5 lb per 100 gal water. Fungicides were applied July 21, August 4, and August 18, 2015 to control Cercospora leaf spot.

Cover crop suppression was evaluated June 10, 2015. Evaluations were a visual estimate of percent biomass reduction in the four treated rows compared to the adjacent untreated strips. Leaf Area Index (leaf area/ground area) was calculated via imagery acquired on July 7, 2015 utilizing a DJI Phantom 3 Professional UAV (DJI - Shenzhen, China) and Easy Leaf Area Software (Plant Sciences Dept. – Univ of CA) for each individual sub-plot. Data were analyzed with the ANOVA procedure of Agricultural Research Manager (ARM), version 2015.6 software package and with the ANOVA procedure as a split-plot analysis to determine interaction effects using SAS Data Management version SAS 9.3 software package.

Timing of cover crop removal in sugarbeet

Experiments were conducted near Prosper, North Dakota in 2015. Urea fertilizer was applied at 80 lb/A and incorporated using a Kongskilde s-tine field cultivator equipped with rolling baskets on April 16, 2015. Wheat was spread perpendicular to plots across the experimental area with a 3-point mounted rotary spreader at 1 bushel per acre and incorporated with tillage prior to planting sugarbeet. Hilleshog 'HM4022RR' sugarbeet treated with Cruiser 5FS at 60 gm ai, Apron XL at 15 gm ai, and Maxim 4FS at 2.5 gm a.i., respectively, per 100,000 seeds was planted 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on April 16, 2015. Counter 20G insecticide at 9 lb/A was applied in a 5-inch band and drag-chain incorporated at planting. Wheat cover crop was terminated by applying glyphosate on various dates that corresponded to wheat growth height. All treatments were applied with a bicycle sprayer at 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. Glyphosate was applied in combination with 'Prefer 90' NIS at 0.25% v/v and 'N-Pak' ammonium sulfate (AMS) at 2.5% v/v.

Table 2. Application information for timing of cover crop removal in sugarbeet, Prosper, ND in 2015.

Application code	A	B	C	D	E
Date	May 20	May 22	May 27	June 2	June 7
Time of Day	6:00 PM	6:00 PM	12:00 PM	3:00 PM	12:30 PM
Air Temperature (F)	67	74	75	78	80
Relative Humidity (%)	23	24	46	51	32
Wind Velocity (mph)	5	3	3.5	15	5
Wind Direction	NW	SE	N	S	NW
Soil Temp. (F at 6")	58	62	58	62	62
Soil Moisture	Good	Good	Good	Wet	Good
Cloud Cover (%)	40	20	5	70	5
Sugarbeet stage (avg)	2 lf	2-4 lf	4 lf	4-6 lf	6 lf
Cover Crop (untreated avg)	2-4"	4"	6"	8"	10-12"

Cercospora leaf spot was controlled with Agri Tin + Topsin at 6 + 7.6 fl oz/A, Proline + Induce at 5 fl oz/A + 0.125% v/v and Headline SC 9 fl oz broadcast on July 16, August 4, and August 27, respectively. Sugarbeet was harvested September 17, 2015 from the center two rows of each plot and weighed. Twenty to thirty pounds of sugarbeet were collected from each plot and analyzed for quality at American Crystal Sugar Quality Lab, East Grand Forks, MN. Experiments were RCBD with eight replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Weed suppression with cover crops in sugarbeet

Experiments were conducted on natural populations of waterhemp, lambsquarters, and redroot pigweed near Moorhead, Minnesota in 2015. The experimental area was tilled using a Kongskilde s-tine field cultivator equipped with rolling baskets on April 30, 2015. Hilleshog 'HM4022RR' sugarbeet treated with Cruiser 5FS at 60 gm ai, Apron XL at 15 gm ai, and Maxim 4FS at 2.5 gm ai, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on April 30, 2015. Wheat at the appropriate weight per area was premeasured and hand-spread across plots to simulate various cover crop density. Assure II at 6 fl oz/A was applied with a bicycle sprayer at 17 gpa through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots on June 2, 2015 to terminate cover crop and improve ease of data collection.

Visual percent broadleaf weed control, weed counts per meter square, and cover crop counts per meter square were collected on June 11, 2015. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Results and Discussion

Impact of soil-applied herbicides on spring-seeded cereal cover crops

Similar experiments were conducted in 2013 and 2014. Oat response to soil-applied herbicides varied by herbicide. Oat was more tolerant of S-metolachor than ethofumesate in experiments conducted near Herman, MN, and Prosper, ND, in 2013 (1, 2). Stand counts, plant height, and visual ground cover from S-metolachlor applied preemergence (PRE) at 0.5 or 1.0 pt/A was similar to the untreated check. Ethofumesate applied PRE at 3 pt/A significantly shortened oat and reduced stand per unit area at Prosper and Herman, but did not affect ground cover at Lake Lillian in 2014 (3).

A barley cover-crop experiment was planted near Foxhome, MN, and wheat cover-crop experiments were planted near Crookston, MN, and Herman, MN, in 2014 (3). As with oat, barley and wheat response to soil-applied herbicides was dependent on herbicide and herbicide rate. S-metolachlor was safer to barley and wheat than ethofumesate. S-metolachlor at 0.5 pt/A tended to be safer to barley and wheat than S-metolachlor at 1 pt/A. Despite the difference in crop response to s-metolachlor rates, there was satisfactory barley and wheat ground cover to protect sugarbeet seedlings from wind or blowing soil, even following application of S-metolachlor at 1 pt/A. In general, oat was more tolerant of S-metolachlor and ethofumesate than barley or wheat and barley was affected less by soil-applied herbicides than wheat.

Water solubility and absorption may partially explain differential herbicide response. S-metolachlor is more water soluble than ethofumesate and is taken up by cereals through the shoot, just above the seed (4). Thus, precipitation moves S-metolachlor past the shoots of developing cereals. Ethofumesate requires more precipitation to move it from the seeding zone and is taken up by both cereal roots and shoots, thus, increasing the potential for injury. Since barley, oat and wheat were planted at different locations and experienced different environmental conditions, comparisons of impact of herbicide and herbicide rate on cover crop injury across cereal species was not possible.

Impact of soil-applied herbicides on spring-seeded barley, oat and wheat cover crops was evaluated at Foxhome, MN, Lake Lillian, MN, and Prosper, ND, in 2015. Barley, oat, and wheat tolerated S-metolachlor or ethofumesate at Prosper, ND, in 2015, presumably because precipitation to activate the herbicides did not occur until four weeks after seeding date or until cereals had germinated and emerged. This outcome demonstrates the importance of the interaction among soil-applied herbicides, spring-seeded cereal cover crops, and precipitation. At Lake Lillian, neither S-metolachlor nor ethofumesate affected barley, oat, or wheat stand. Ethofumesate at 2 pt/A tended to reduce barley, oat, and wheat visual ground cover compared to ethofumesate at 1 pt/A, S-metolachlor at 0.5 or 1 pt/A, and the untreated check. Similarly to the results from Prosper, the results from Lake Lillian presumably are attributed to lack of significant precipitation the first two weeks after planting.

Barley, oat, and wheat response to soil-applied herbicides varied by herbicide and rate at Foxhome (Table 3, Figure 1). S-metolachlor or ethofumesate, soil-applied, damaged oat the least and wheat the most. S-metolachlor at 0.5 pt/A was safest of all herbicide treatments evaluated, but reduced barley, oat, and wheat ground cover compared to the untreated check. Increasing the S-metolachlor rate from 0.5 to 1 pt/A decreased oat, barley and, wheat ground cover. Ethofumesate injured cover crops more than S-metolachlor. Oat tolerated ethofumesate at 1 pt/A, but oat ground cover was reduced from ethofumesate at 2 pt/A. Ethofumesate at either 1 or 2 pt/A significantly reduced barley and wheat ground cover compared to S-metolachlor at 0.5 pt/A.

Table 3. Impact of soil-applied herbicide on barley, oat, and wheat ground cover 35 days after planting near Foxhome, MN 2015

Herbicide Treatment	Rate	Barley[2]	Oat	Wheat	Treatment Average[4]
	pt/A	-----------------% visual ground cover-----------------			
No Soil-Applied[1]		100	96	100	99
s-Metolachlor	0.5	63	81	29	58
s-Metolachlor	1.0	15	49	10	25
Ethofumesate	1.0	15	46	8	23
Ethofumesate	2.0	15	18	13	22
Cover crop Average[3]		46	58	32	

[1]LSD (0.10) for cover crops within a treatment = 14
[2]LSD (0.10) treatments within a cover crop = 16
[3]LSD (0.10) between cover crop averages = 9
[4]LSD (0.10) between treatment averages = 9

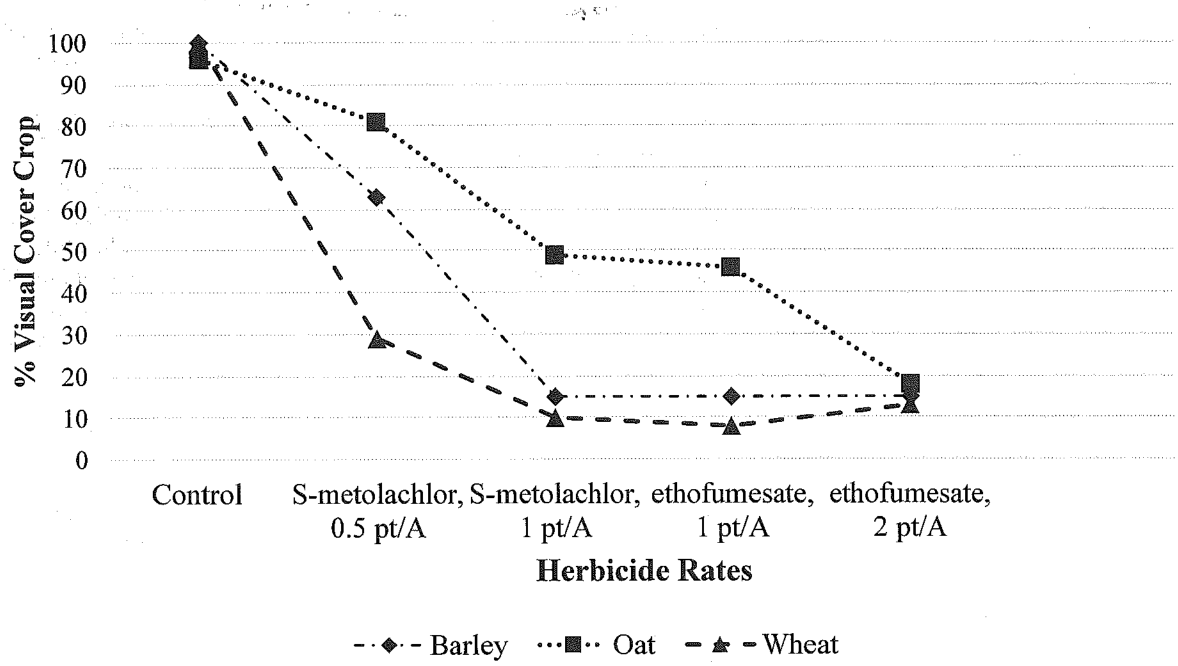

Figure 1. Impact of soil-applied herbicides and herbicide rate on Barley, oat and wheat visual ground cover, 35 days after planting, Foxhome, MN, 2015

Soils at Foxhome are a sandy loam. S-metolachlor and ethofumesate are less readily adsorbed to course textured soils and, thus, are activated more easily into soils at the Foxhome location by precipitation. The experiment was scheduled for planting when rainfall was in the forecast to increase the potential impact of soil-applied herbicides on cover crops. Sufficient precipitation to incorporate S-metolachlor or ethofumesate occurred within 48 hours after herbicide application (communication with Mr. Mike Metzger.

Three years' experience evaluating the effect of soil-applied herbicides on spring seed cereals as cover crops indicates:: a) oat tolerates soil-applied herbicides the best followed by barley and then wheat; b) S-metolachlor is safer to barley and wheat than ethofumensate; c) apply S-metolachlor at 0.5 to 1 pt/A and/or ethofumesate at 1 pt/A with oat and S-metolachlor at 0.5 pt/A with barley and wheat ; d) soil-applied herbicides are more injurious to cover crops on course textured soils than fine or medium textured soils; and e) rainfall within 48 to 72 hours after planting may influence herbicide response to cover crops, regardless of soil texture.

Timing of cover crop removal in sugarbeet

At the 90% confidence level, sugarbeet yield (Pr>F 0.0305) and extractable sugar (Pr>F 0.0764) were influenced by the timing of wheat cover crop removal whereas percent sugar (Pr>F 0.3526) was not (Table 4). Sugarbeet yield (tons/A and lb/A extractable sucrose) was greatest when wheat, seeded as a companion crop just prior to sugarbeet, was terminated no later than the 4-leaf sugarbeet stage. The experiment tended to demonstrate a sugarbeet yield and extractable sugar advantage from sugarbeet seeded with a wheat cover crop compared to sugarbeet seeded without a cover crop.

Cover crops need to be carefully managed after emergence. Sugarbeet cooperative agriculturalist recommend terminating cover crops when sugarbeet are at the 2 to 4-leaf stage. Results of this experiment tend to support the recommendation, especially if the time required before herbicide kills the cover crop is considered. Cover crop species are actively growing during spring weather conditions and create a mat of high albedo reflection that rob heat units from slower growing sugarbeet seedlings. Cover crops also create a very heavy below ground root mass, analogous to an 'iceberg' in ocean waters, that is competing with the sugarbeet plant for moisture and nutrients. Finally, cover crops will continue to protect sugarbeet seedlings from wind or blowing soil even after they have been terminated with herbicide. That is, the carcasses from dead cereal grasses will protect the sugarbeet seedling several weeks or until the sugarbeet plant is able to withstand wind and blowing soil.

Table 4. Effect of timing of wheat cover crop removal on sugarbeet yield, percent sugar, and extractable sucrose at Prosper, ND in 2015.

Sugarbeet stage at wheat termination	Wheat height at termination	Yield	Sugar	Extractable sucrose
no. of leaves	inches	ton/A	%	lb/A
No Cover Crop	n/a	35.3 ab	17.0	11,051 ab
2	2	36.0 a	16.9	11,253 a
3	4	36.6 a	16.5	11,173 ab
4	6	35.5 ab	16.8	10,929 abc
5	8	33.8 b	16.7	10,373 c
6	10-12	34.0 b	16.9	10,644 bc
LSD (0.10)		1.6	NS	542
CV		5	3	6

Weed suppression with cover crops in sugarbeet

There were on average 221 broadleaf weeds per meter square in plots not seeded with wheat cover crop in the experiment at Moorhead, MN (Table 5). Weeds observed were lambsquarters, redroot pigweed, common cocklebur, common ragweed, and biennial wormwood. Seeding wheat cover crop with sugarbeet provided weed suppression. Numerically, there was a 52% reduction in broadleaf weeds when wheat was seeded as a companion crop with sugarbeet at 45 lb/A (approximately ¾ bushel). Increasing the seeding rate from 45 pound to 90 increased visual broadleaf control. There was no significant benefit from increasing the wheat seeding rate from 90 to 180 lb/A.

Farmers seed cover crops with sugarbeet for several reasons. Seeding rate usually is between half and three-quarter bushel depending on cereal species according to farmers and agriculturalists. This experiment indicated that in addition to the other benefits, cover crops suppressed broadleaf weed emergence. Results suggest the maximum weed suppression benefit was at approximately 1.5 bu/A or 2 to 3 times the seeding density currently used by farmers.

Table 5. Broadleaf weed suppression from wheat cover crop seeded at various density at Moorhead, MN in 2015.

Wheat Seeding Rate	Cover Crop Density	Visual Broadleaf Weed Control	Weed Density
lb/A	plants/m^2	%	plants/m^2
0	34	15	221
45	143	55	105
90	150	75	81
180	358	85	30
LSD(0.10)	56	19	83
CV	24	25	59

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KOCHIA CONTROL IN SUGARBEET - A PROGRESS REPORT

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Summary

1. Ethofumesate (Nortron) should be soil-applied at 7 to 7.5 pt/A in sugarbeet fields with known kochia history.
2. Scout fields with known or suspected kochia history and spray with a tank-mixture including Betamix, ethofumesate and UpBeet when kochia is 1-inch tall and sugarbeeet is at the 2-leaf stage.
3. Make two or three repeat applications of UpBeet at 0.5 to 0.75 oz/A plus ethofumesate and glyphosate beginning when kochia is 2 inches tall and sugarbeet are at the 2 to 4 leaf stage.

Introduction

Kochia is an annual broadleaf weed in the Chenopodium family. Kochia is one of the first weeds to emerge in the spring and can withstand early-season frost. Kochia grows erect and is highly branched from the central stem. Kochia is a bush style plant that, at harvest, averages three to five feet tall. Kochia is extremely competitive with crops such as soybean, dry bean, or sugarbeet. In sugarbeet, Schweizer found that five kochia plants per 100 feet of row reduced yield by 10%. Kochia produces approximately 14,000 seed per plant. However, kochia seed viability is short, usually two years or less. There has been confirmed resistance to multiple herbicide families including ALS (Site of Action (SOA) 2), triazine (SOA 5) and glyphosate (SOA 9) chemical family herbicides.

Kochia historically was found in pastures, road ditches, and waste areas on farms but has evolved to flourish in cultivated fields. Kochia is extremely deep rooted and can grow in places that do not receive much rainfall. Kochia also is able to tolerate high salinity soils. Kochia leaves are alternate on the stem and are long and narrow, up to two inches long and less than half inch wide. Leaves are usually without petioles (leaf stems) and often have hairy margins. The young shoots are usually very hairy.

Kochia is associated with arid environments. However, it, along with many tough-to-control weeds, seems to be adapting too many different environments. While waterhemp may currently be receiving more attention in the media, kochia might have greater long-term impacts on sugarbeet farmers, primarily because there are very few herbicide options in sugarbeet. The purpose and objective for the research was to investigate control of glyphosate tolerant kochia in sugarbeet.

Materials and Methods

An experiment was conducted on natural populations of kochia near Barney, ND. Experimental area was prepared using a Kongskilde s-tine field cultivator with rolling baskets on April 23, 2015. The experiment was planted into corn stalks residue. Hilleshog 'HM4022RR' sugarbeet seed treated with Cruiser 5FS at 60 gm ai, Apron XL at 15 gm ai, and Maxim 4FS at 2.5 gm a.i., respectively, per 100,000 seeds was planted on April 23, 2015, 1.25 inches deep in 22-inch rows at 60,825 seeds per acre. Herbicide treatments were applied at 17 gallons per acre spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 pounds per square inch to the center four rows of six-row plots 30 feet in length (Table 1). Ammonium sulfate (AMS) in all treatments was a liquid formulation from Winfield Solutions marketed as 'N-Pak' AMS. The Barney, ND, location contained moderate levels of glyphosate-resistant kochia. Sequential herbicide applications corresponded to kochia size and were made on April 23, May 21, May 27, June 4, and June 29, 2015. Assure II was applied across the experimental area for controlling volunteer corn. Experiment was randomized complete block design with four replications. Sugarbeet injury and kochia control were evaluated June 8, June 19, July 7, and August 4, 2015. All evaluations were a visual estimate of fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Data was analyzed with the ANOVA procedure of Agricultural Research Manager (ARM), version 2015.6 software package.

Table 1. Application information for kochia control in sugarbeet experiment, Barney, ND, 2015.

Application code	A	B	C	D	E
Date	April 23	May 21	May 27	June 4	June 29
Time of Day	2:00 PM	1:15 PM	4:00 PM	6:00 PM	1:00 PM
Air Temperature (F)	51	66	85	86	77
Relative Humidity (%)	20	29	50	35	63
Wind Velocity (mph)	6	2.5	3	15	4.5
Wind Direction	E	NW	NE	NW	N
Soil Temp. (F at 6")	45	56	72	74	68
Soil Moisture	Good	Good	Good	Good	Good
Cloud Cover (%)	25	0	50	0	100
Sugarbeet stage (avg)	PRE	2 lf	4 lf	6 lf	10 lf
Kochia (untreated avg)	-	1.0"	1.5"	1.75"	12"

Results and Discussion

There was early season sugarbeet injury in this experiment (Table 2). Sugarbeet injury was greatest at the June 8 and June 19 evaluations and was less in July and generally negligible in August (July and August data not presented). Sugarbeet injury numerically was greatest at 30% from preemergence (PRE) ethofumesate at 7 pt/A followed by (fb) Betamix at 10 fl oz/A + UpBeet at 1 oz/A + ethofumesate at 4 fl oz/A at the 2-leaf sugarbeet stage fb Roundup PowerMax + ethofumesate at 4 fl oz/A + Betamix at 12, 24, and 32 fl oz/A. Roundup PowerMax + ethofumesate at 4 fl oz/A + Betamix at 16, 24, and 32 fl oz/A gave 19% injury compared to 24% injury from the same treatment following PRE ethofumesate at 7.5 pt/A. Three applications of PowerMax + Stinger at 2 fl oz/A + UpBeet at 0.5 oz/A gave 20% injury.

At evaluation timings, the experiment contained a heavy infestation of lambsquarters and kochia and a light infestation of redroot pigweed, barnyardgrass and foxtail species. Lambsquarters control with all treatments in the experiment was near perfect throughout the growing season (data not presented). All treatments contained Roundup PowerMax plus surfactant (either Prefer 90 non-ionic surfactant (NIS) or Destiny HC high surfactant methylated oil concentrate (HSMOC) and N-Pak AMS). Environmental conditions at application were ideal to maximize herbicide efficacy and all weeds were actively growing.

Two applications of Roundup PowerMax at 28 fl oz/A at the 4- and 6-leaf sugarbeet stage fb PowerMax at 22 fl oz/A at the 10-leaf stage gave only 70% kochia control when averaged across four evaluations, indicating there was glyphosate-resistant kochia at the Barney, ND location (Table 2). Increasing the PowerMax rate from 28 to 32 fl oz/A or addition of ethofumesate at 4 fl oz/A did not improve kochia control. Applying Betamix sequentially at 8, 12, 16 or 16, 24 or 32 fl oz/A + Roundup Power Max + ethofumesate improved kochia control but also caused more sugarbeet injury.

Ethofumesate applied PRE at 7.5 pt/A fb three applications of PowerMax + ethofumesate did not improve control. Poor kochia control may be due to lack of precipitation following planting. Precipitation during the 14 days following PRE ethofumesate application totaled only 0.25 inches and the first significant rainfall event (0.92 inches) occurred 18 days after planting. By this time, kochia had already emerged and was actively growing.

Kochia control numerically was greatest across evaluations from PRE ethofumesate at 7 pt/A fb Betamix at 10 fl oz/A + UpBeet at 1 oz/A + ethofumesate at 4 fl oz/A at the 2-leaf stage fb three applications of Roundup PowerMax + ethofumesate at 4 fl oz/A + Betamix at 12, 24 and 32 fl oz/A. However, this treatment caused 30% sugarbeet injury which is unacceptable to most growers and would be very costly.

A better compromise between crop safety and kochia control was from PRE ethofumesate at 7 pt/A fb ethofumesate at 12 fl oz/A + Betamix at 10 fl oz/A+ UpBeet at 1 oz/A at the 2-leaf stage fb three applications of Roundup PowerMax. Three applications of Roundup PowerMax + ethofumesate at 4 fl oz/A + UpBeet at 0.5 oz/A also gave very good control, especially as the season progressed. Growers, however, will need to accept some sugarbeet injury to achieve acceptable kochia control.

Table 2. Sugarbeet injury and kochia control from soil-applied and postemergence herbicide treatments, Barney, ND, 2015.

Treatment[1]	Rate	Application Code[2]	Sgbt injury		Kochia control			
			Jun 8	Jun 19	Jun 8	Jun 19	Jul 7	Aug 4
	pt/A, fl oz/A or oz/A		-----%-----					
PMax[3] / PMax / PMax	28 / 28 / 22	C / D / E	9	0	65	63	78	75
PMax / PMax / PMax	32 / 24 / 22	C / D / E	0	4	63	58	68	70
PMax+Etho / PMax+Etho / PMax+Etho	28+4 / 28+4 / 22+4	C / D / E	3	10	58	63	75	70
PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	28+4+8 / 28+4+12 / 22+4+16	C / D / E	8	14	74	76	78	76
PMax+Etho+Bmix/ PMax+Etho+Bmix/ PMax+Etho+Bmix	28+4+16 / 28+4+24 / 22+4+32	C / D / E	19	18	68	79	86	78
Etho / PMax+Etho / PMax+Etho / PMax+Etho	7/ 28+4 / 28+4 / 22+4	A / C / D / E	9	5	85	70	73	70
Etho / PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	7 / 28+4+10 / 28+4+16 / 22+4+24	A / C / D / E	24	23	76	81	83	83
PMax+Sting+UpB / PMax+Sting+UpB / PMax+Sting+UpB	28+2+0.5 / 28+2+0.5 / 22+2+0.5	C / D / E	20	23	78	73	73	73
PMax+Etho+UpB / PMax+Etho+UpB / PMax+Etho+UpB	28+4+0.5 / 28+4+0.5 / 22+4+0.5	C / D / E	4	11	81	89	86	84
Etho / Etho+Bmix+UpB / PMax/ PMax /PMax	7 /12+10+1 / 28 / 28 / 22	A / B / C / D / E	11	10	91	88	88	85
Etho / Etho +Bmix+UpB / PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	7 /3+10+1 / 28+3 +12 / 28+3+24 / 22+3+34	A / B / C / D / E	30	29	90	91	93	86
LSD (0.10)			**11**	**11**	**9**	**11**	**11**	**10**

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[2]Application codes refer to the information in Table 1.
[3]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8; UpB=UpBeet; Sting=Stinger.

Premergence ethofumesate and/ or three applications of Roundup Power Max + ethofumesate + UpBeet seemed to be the best treatment to control kochia without causing sugarbeet injury. Treatments containing Betamix gave more sugarbeet injury when following PRE ethofumesate.

Future Research

We will continue to conduct experiments with kochia in sugarbeet in 2016. Plant early if the goal is to improved kochia research or consider delaying planting until after the first flush of kochia if the goal is sugarbeet production. We learned that timely rainfall for ethofumesate activation is critical to kochia management in 2015. Our 2016 experiments will continue to develop a kochia management system in sugarbeet and crops grown in sequence with sugarbeet including corn and soybean.

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FEATURED WEED
VOLUNTEER ROUNDUP READY CANOLA CONTROL IN SUGARBEET

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Summary

1. Use sequential applications of UpBeet at 0.75 and 1.0 oz/A beginning when volunteer Roundup Ready (RR) canola is at the 2-leaf stage.
2. Experiments planted in April suggest sugarbeet injury from UpBeet when applied under cool and excessively wet conditions.
3. Ethofumesate PRE at 7.5 pt/A did not provide acceptable volunteer canola control.
4. Betamix or ethofumesate plus UpBeet did not improve volunteer canola control compared to UpBeet alone.

Introduction

Canola is planted in sequence with sugarbeet fields in northern counties in the Red River Valley. In the course of growing and harvesting canola, seeds are inadvertently scattered on the soil surface and germinate and emerge in subsequent crops. Gulden reported average canola losses of 3,000 viable seeds per meter square or a seed number greater than the normal canola seeding rates (2). Canola may also arrive in a field inconspicuously. Canola allegedly has been found at trace levels with phosphorus or potassium fertilizer spread on fields.

Volunteer canola has been reported to persist in soils for at least four years and as many as seven years (1, 4). However, the majority of volunteer canola seeds germinate and emerge the year following the canola crop (3). Weedy characteristics such as long seedbank persistence and secondary dormancy contribute to the abundance and recurrence of canola as a weed in fields planted to sugarbeet. These occurrences have been compounded by the development and commercial release of herbicide-resistant canola genotypes containing the Roundup Ready trait.

Growers must implement a strategic approach for controlling volunteer canola by carefully considering crop sequence and herbicide options. Like many crops, volunteer canola is primarily Roundup Ready, requiring sugarbeet farmers to manage canola in sugarbeet much like they manage corn or soybean in sugarbeet. Further compounding the problem, canola is difficult to distinguish from wild mustard at the early vegetative stage when it is easiest to control.

The objective of this experiment was to determine an herbicide program including the best herbicide application timing for control of volunteer RR canola in sugarbeet.

Materials and Methods

Experiments were conducted at the North Dakota State University, Prosper Research Farm in 2015. The experimental area was seeded with Roundup Ready canola using a hand-operated spreader to simulate volunteer RR canola. Wheat stubble was prepared for planting using a Kongskilde s-tine field cultivator equipped with rolling baskets on April 16, 2015 (first experiment) and on May 27, 2015 (second experiment). Hilleshog HM4022RR sugarbeet seed treated with Cruiser 5FS at 60 gm a.i., Apron XL at 15 gm a.i., and Maxim 4FS at 2.5 gm a.i., respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on April 16 and May 27, 2015.

Herbicide treatments were multiple herbicide applications beginning when canola was at the cotyledon or two-leaf stage. In the first experiment, herbicides were applied preemergence (PRE) on April 17, 2015 and postemergence (POST) on May 9, May 20, May 24, June 5 and June 19, 2015, depending on treatment and application timing. In the second experiment, herbicides were applied PRE on May 27, 2015 and POST on June 8, June 19, June 24 and July 9, 2015. UpBeet herbicide was applied at 0.25, 0.5, and 0.75 oz/A in the first experiment. Herbicide rate was increased to 0.5, 0.75, and 1 oz/A in the second following conversation with technical specialists at Dupont. 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 an experimental area with a moderate level infestation of RR canola. Ammonium sulfate (AMS) in all treatments was a liquid formulation from Winfield Solutions called 'N-Pak' AMS.

Sugarbeet injury was evaluated on June 10, June 29, and July 8, 2015 and weed control was evaluated on June 10, June 29, July 8, and August 2, 2015 for the first experiment. Sugarbeet injury was evaluated on July 13 and August 2, 2015 while weed control was evaluated on July 13, August 2, and August 24, 2015 for the second experiment. 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, 2015.6 software package and with the ANOVA procedure as a factorial analysis to determine effects between application timings using SAS Data Management version SAS 9.3 software package.

Table 1. Application information for April 17 planting, volunteer RR canola control, Prosper, ND, 2015.

Application code	A	B	C	D	E	F
Date	April 17	May 9	May 20	May 24	June 5	June 19
Time of Day	4:00 PM	12:00 PM	6:00 PM	8:30 AM	10:00 AM	9:00 AM
Air Temperature (F)	70	40	67	64	68	68
Relative Humidity (%)	16	52	23	45	53	58
Wind Velocity (mph)	12	9.5	5	4	6	12
Wind Direction	NW	NE	NW	NE	ESE	W
Soil Temp. (F at 6")	47	42	58	59	60	59
Soil Moisture	Dry	Good	Good	Dry	Dry	Good
Cloud Cover (%)	5	90	40	100	90	40
Sugarbeet stage (avg)	PRE	Cot.	2 lf	4 lf	6 lf	10 lf
Canola (untreated avg)	-	Cot.	2 lf	2 lf	5 lf	18"

Table 2. Application information for May 27 planting, volunteer RR canola control, Prosper, ND, 2015.

Application code	A	B	C	D	E
Date	May 27	June 7	June 19	June 24	July 9
Time of Day	10:40 AM	1:00 PM	9:00 AM	9:00 AM	10:30 AM
Air Temperature (F)	75	81	68	76	74
Relative Humidity (%)	46	32	58	50	50
Wind Velocity (mph)	3.5	5	12	4	2
Wind Direction	N	NW	W	W	N
Soil Temp. (F at 6")	58	64	59	68	68
Soil Moisture	Dry	Dry	Good	Good	Good
Cloud Cover (%)	0	5	50	25	10
Sugarbeet stage (avg)	PRE	Cot.	4 lf	5 lf	12 lf
Canola (untreated avg)	-	Cot.	2 lf	4 lf	24"

Results and Discussion

Sugarbeet injury from herbicide treatments was dependent on environment (early or late planting) and timing of the first UpBeet application (Table 3,4). In the early planting, sugarbeet injury was greatest at the first evaluation timing and decreased at the second and third evaluation (Table 3). Herbicide treatments at the cotyledon canola stage caused greater sugarbeet injury than herbicide treatments at the 2-leaf canola stage. UpBeet was applied at 0.25, 0.5 and 0.75 oz/A plus Roundup PowerMax. Sugarbeet injury from UpBeet at 0.25 /0.25 / 0.25 oz/A plus Roundup PowerMax was similar to sugarbeet injury from UpBeet at 0.5 / 0.5 / 0.5 oz/A. UpBeet at 0.75 / 0.75 / 0.75 oz/A plus Roundup PowerMax caused more sugarbeet injury, especially when herbicide treatments were initiated at the cotyledon canola stage. However, there was no difference in sugarbeet injury across UpBeet rates when treatments were initiated at the 2-leaf stage. UpBeet at 0.5 / 0.5 / 0.5 plus Betamix at 8 / 12 / 16 fl oz/A, respectfully, plus Roundup PowerMax caused more sugarbeet injury than UpBeet plus Roundup PowerMax alone when averaged across evaluations and application timing.

There was much less sugarbeet injury in the late planted experiment even though UpBeet rates were increased from 0.25, 0.5 and 0.75 oz/A to 0.5, 0.75 and 1.0 oz/A (Table 4). There was no difference in sugarbeet injury from herbicide treatments initiated at the cotyledon canola stage compared to the same herbicide treatments initiated at the 2-leaf canola stage. Similar to the early experiment, Betamix or ethofumesate applied in combination with UpBeet plus PowerMax caused more sugarbeet injury than UpBeet plus Roundup PowerMax alone.

Table 3. Sugarbeet injury from multiple applications of UpBeet alone and in tank mixtures at cotyledon and 2-leaf canola stage, early planting, Prosper, ND, 2015.

Treatment[1]	Rate	Cotyledon stage[5] Jun 10	Jun 29	July 8	2-leaf stage Jun 10	Jun 29	July 7	Treatment Means[4]
	pt, fl oz/or oz/A	%						
PMax[2] / PMax / PMax	28 / 28 / 28	0	5	11	-	-	-	5
Etho / PMax / Pmax / PMax	7.5 / 28 / 28 /22	3	0	8	-	-	-	4
UpBeet + P Max[6] / UpBeet + PMax / UpBeet + PMax	0.25 + 28 / 0.25 + 28 / 0.25 + 22	29	15	11	10	15	3	14
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.5+ 28 / 0.5+ 28 / 0.5+ 22	25	8	11	14	5	3	11
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.75 +2 8 / 0.75 + 28 / 0.75 + 22	40	8	11	8	15	3	14
UpBeet + Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	0.25 +8 + 28 / 0.25 +12+28 / 0.25 +16+22	23	10	10	19	10	13	14
UpBeet + Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	0.5 + 8 + 28 / 0.5 + 12 + 28 / 0.5 + 16 + 22	38	20	11	25	13	11	20
UpBeet + Etho + PMax / UpBeet + Etho + PMax / UpBeet + Etho + PMax	0.25 + 4 + 28 / 0.25 + 4 + 28 / 0.25 + 4 + 22	30	11	9	15	18	13	16
Evaluation Timing Means		31	14	10	15	13	8	
Application Timing Means[3]			18			12		

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8.
[3]LSD (0.10) across application timing averages = 4
[4]LSD (0.10) between treatment averages = 6
[5]LSD (0.10) treatment means within an application timing = 11
[6]LSD (0.10) for treatment means across application timings = 10

Table 4. Sugarbeet injury from sequential applications of UpBeet alone and in tank mixtures at cotyledon and 2-leaf canola stage application timing, late planting, Prosper, ND, 2015.

Treatment[1]	Rate	Cotyledon stage[5]		2-leaf stage		Treatment Means[4]
		Jul 13	Aug 2	Jul 13	Aug 2	
	pt, fl oz or oz/A	---------	---------	-----%-----	---------	---------
PMax[2] / PMax / PMax	28 / 28 / 28	0	0	-	-	0
Etho / PMax / Pmax / PMax	7.5 / 28 / 28 / 22	0	0	-	-	0
UpBeet + PMax[6] / UpBeet + PMax / UpBeet + PMax	0.5 + 28 / 0.5 + 28 / 0.5 + 22	0	0	11	0	3
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.75 + 28 / 0.75 + 28 / 0.75 + 22	3	0	0	3	2
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	1.0 + 28 / 1.0 + 28 / 1.0 + 22	3	3	8	3	4
UpBeet + Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	0.5 + 8 + 28 / 0.5 + 12 + 28 / 0.5 + 16 + 22	16	8	10	5	10
UpBeet + Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	1.0 + 8 + 28 / 1.0 + 12 + 28 / 1.0 + 16 + 22	11	5	17	3	9
UpBeet + Etho + PMax / UpBeet + Etho + PMax / UpBeet + Etho + PMax	1.0 + 4 + 28 / 1.0 + 4 + 28 / 1.0 + 4 + 22	10	0	3	3	4
Evaluation Timing Means		7	3	8	3	
Application Timing Means[3]		5		6		

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8.
[3]LSD (0.10) across application timing averages = NS
[4]LSD (0.10) between treatment averages = 5
[5]LSD (0.10) treatment means within an application timing = 9
[6]LSD (0.10) for treatment means across application timings = 9

Precipitation and air temperature may partially explain the differences in sugarbeet injury across planting dates and application timing. Postemergence herbicides were sprayed on May 9 and May 20, depending on canola growth stage. Temperatures averaged 47 F during this 11-day interval and 4.8 inches of precipitation. Temperatures averaged 66 F with 2.0 inches of precipitation during the same interval in the second planting.

Canola control was percent visual growth reduction noted by comparing the treated rows to the border rows of the plot (Table 5). Close attention was given to flowering canola during the third evaluation since flowers would imply potential development of new seed and further proliferation of volunteer canola. Canola control from herbicide treatments applied at the 2-leaf canola stage was greater than treatments initiated at the cotyledon stage. Canola control improved as UpBeet rate increased. UpBeet at 0.5 /0.5 / 0.5 oz/A plus Roundup PowerMax gave greater canola control than UpBeet at 0.25 / 0.25 / 0.25 oz/A plus Roundup PowerMax. UpBeet at 0.75 / 0.75 / 0.75 oz/A plus Roundup PowerMax gave greater canola control than UpBeet at 0.5 / 0.5 / 0.5 oz/A plus Roundup PowerMax and similar control to UpBeet at 1.0 / 1.0 / 1.0 oz/A plus PowerMax. Addition of Betamix or ethofumesate did not improve control compared to UpBeet and Roundup PowerMax alone.

Canola control was greater in the late planted experiment than the early planting and is attributed to increasing the UpBeet rate from 0.25, 0.5 and 0.75 oz/A to 0.5, 0.75 and 1.0 oz/A (Table 6). Canola control was greater as the UpBeet rate increased. There was no statistical difference in canola control from herbicide treatments initiated at the cotyledon stage compared to canola treatments initiated at the 2-leaf stage. Adding Betamix or ethofumesate with UpBeet and PowerMax tended to improve canola control when herbicide application began at the cotyledon stage but did not improve control when applications began at the 2-leaf stage.

Table 5. RR Canola control from sequential applications of UpBeet alone and in tank mixtures at cotyledon and 2-leaf canola stage application timing, early planting, Prosper, ND, 2015.

Treatment[1]	Rate	Cotyledon stage[5] Jun 29	July 8	Aug 2	2-leaf stage Jun 29	July 8	Aug 2	Treatment Means[4]
	pt, fl oz/A or oz/A	--------	--------	--------	%	--------	--------	--------
PMax[2] / PMax / PMax	28 / 28 / 28	0	0	0	-	-	-	0
Etho / PMax / Pmax / PMax	7.5 / 28 / 28 / 22	43	31	30	-	-	-	35
UpBeet +PMax[6] / UpBeet + PMax / UpBeet + PMax	0.25 + 28 / 0.25 + 28 / 0.25 + 22	69	56	58	75	60	60	63
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.5+ 28 / 0.5 + 28 / 0.5 + 22	81	68	65	93	78	75	77
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.75 + 28 / 0.75 + 28 / 0.75 + 22	89	79	66	95	81	74	81
UpBeet + Bmix + PMax / UpBeet + Bmix +PMax / UpBeet + Bmix + PMax	0.25 +8+ 28 / 0.25 + 12+ 28 / 0.25 + 16 +22	79	56	59	74	61	68	66
UpBeet + Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	0.5 + 8 + 28 / 0.5 + 12+ 28 / 0.5 + 16 +22	81	66	61	83	71	69	72
UpBeet + Etho + PMax / UpBeet + Etho + PMax / UpBeet + Etho + PMax	0.25 + 4 +28 / 0.25 + 4 +28 / 0.25 + 4+22	78	60	51	83	63	59	66
Evaluation Timing Means		80	64	60	84	69	68	
Application Timing Means[3]			68			73		

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8.
[3]LSD (0.10) across application timing averages = 2
[4]LSD (0.10) between treatment averages = 4
[5]LSD (0.10) treatment means within an application timing = 3
[6]LSD (0.10) for treatment means across application timings = 6

Canola germinated pattern may have influenced results from both the early and late planted experiments. Canola continued to germinate and emerge, even after herbicide sprays were initiated. Later application timing (2-leaf canola) tended to provide greater canola control presumably because herbicide treatments were applied over a broader window of time and may have been sprayed over later germinating canola that was missed when herbicide treatments were initiated at the cotyledon canola stage. Late germinating canola that did not receive repeat herbicide applications grew and in some cases began to flower.

Delaying application timing conflicts with experience. Volunteer canola control in Canada historically was best when herbicide treatments began when canola was at the cotyledon stage (conversation with Peter Regitnig, Agronomist, Lantic Sugar). However, reduction in the UpBeet price has made it affordable to use UpBeet at greater rates, which possibly has expanded the application window.

Additional use of Betamix or ethofumesae with UpBeet plus Roundup Power Max gave conflicting results in these experiments. Canola control from addition of Betamix or ethofumesate did not improve canola control from UpBeet plus Roundup in the early planted experiment. Canola control tended to increase when Betamix or ethofumesate was mixed with UpBeet and PowerMax in the late planted experiment and when herbicide treatments were initiated at the cotyledon stage; however, the Betamix or ethofumesate plus UpBeet and PowerMax did not improve canola control when herbicide treatments were initiated at the 2-leaf stage in the second experiment. Ethofumesate at 7.5 pt/A followed by Roundup PowerMax did not provide adequate canola control in either experiment and, as expected, Roundup PowerMax alone did not provide any control of RR canola.

Table 6. RR Canola control from sequential applications of UpBeet alone and in tank mixtures at cotyledon and 2-leaf canola stage application timing, late planting, Prosper, ND, 2015.

		Cotyledon stage[5]			2-leaf stage			
Treatment[1]	Rate	July 13	Aug 2	Aug 24	July 13	Aug 2	Aug 24	Treatment Means[4]
	pt, fl oz/A or oz/A	%						
PMax[2] / PMax / PMax	28 / 28 / 28	0	23	14	-	-	-	12
Etho / PMax / Pmax / PMax	7.5 / 28 / 28 / 22	45	44	38	-	-	-	42
UpBeet + PMax[6] / UpBeet + PMax / UpBeet + PMax	0.5 + 28 / 0.5 + 28 / 0.5 + 22	86	80	60	85	78	66	76
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	0.75 + 28 / 0.75 + 28 / 0.75 + 22	92	86	65	93	80	65	80
UpBeet + PMax / UpBeet + PMax / UpBeet + PMax	1.0 + 28 / 1.0 + 28 / 1.0 + 22	94	93	66	96	91	76	86
UpBeet +Bmix + PMax / UpBeet + Bmix + PMax / UpBeet + Bmix + PMax	0.5 + 8 + 28 / 0.5 + 12 + 28 / 0.5 + 16+22	91	81	56	91	78	56	76
UpBeet +Bmix + PMax / UpBeet + Bmix+ PMax / UpBeet + Bmix+ PMax	1.0 + 8+28 / 1.0 + 12+ 28 / 1.0 + 16 +22	97	91	68	88	79	63	81
UpBeet + Etho + PMax / UpBeet + Etho + PMax / UpBeet + Etho + PMax	1.0 +4 + 28 / 1.0 +4 + 28 / 1:0 + 4 +22	97	96	75	95	86	73	87
Evaluation Timing Means		93	91	54	88	82	67	
Application Timing Means[3]			80			82		

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8.
[3]LSD (0.10) across application timing averages = 2
[4]LSD (0.10) between treatment averages = 6
[5]LSD (0.10) treatment means within an application timing = 11
[6]LSD (0.10) for treatment means across application timings = 10

Conclusions

Treatments applied at the cotyledon stage caused greater sugarbeet injury and less canola control than treatments initiated at the 2-leaf stage. Canola control was better from UpBeet at 0.75 and 1 oz/A than from UpBeet at 0.25 and 0.5 oz/A across application timing. However, sugarbeet injury potential increased as UpBeet rate increased, especially under cold and wet conditions experienced in the first planting. There was no advantage to adding Betamix or ethofumesate to UpBeet in these experiments.

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Future Research

Future experiments shall include sequential applications of UpBeet at 0.5, 0.75, and 1 oz/A since UpBeet at 0.25 oz/A did not provide adequate control. Canola was sprayed at the cotyledon or two-leaf stage to maximize control. Farmers and Agriculturalist that attended the Prosper field tour indicated volunteer canola frequently is misidentified and often is at the four-leaf stage before herbicide application. They suggested it would be useful to evaluate canola control at the cotyledon and two-leaf stage with canola control at the four-leaf stage.

KOCHIA CONTROL IN CORN – BARNEY, ND

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The objective of this experiment was to demonstrate a systems approach for controlling kochia in corn using herbicides that allow sugarbeet to be grown the next season while using herbicide sites of action that differ from glyphosate.

MATERIALS AND METHODS

An experiment was conducted on natural kochia populations near Barney, ND in 2015. The field site was cultivated twice with a Kongskilde 's-tine' field cultivator on May 21, 2015. 'DKC38-04RIB' corn was seeded in 22-inch rows at 34,600 seeds per acre on May 21. 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 30-feet in length. Preemergence (PRE) treatments were applied immediately following planting (Table 1). Roundup PowerMax at 30 fl oz/A was applied May 28, prior to corn emergence, to control common lambsquarters that had survived spring tillage. Postemergence (POST) treatments were applied June 15 and June 29. Corn injury was evaluated on June 24, July 7, and August 4 while weed control was evaluated July 7 and August 4. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A	B	C
Date	21 May	15 June	29 June
Time of Day	1:15 PM	12:30 PM	10:45 AM
Air Temperature (F)	66	75	73
Relative Humidity (%)	29	47	71
Wind Velocity (mph)	3	9	4
Wind Direction	NW	N	W
Soil Temp. (F at 6")	56	65	68
Soil Moisture	Slightly Wet	Slightly Dry	Slightly Wet
Cloud Cover (%)	0	10	100
Corn stage (avg)	PRE	V5	V8
Kochia	-	5 inch	12 inch
Common Lambsquarters	-	1.5 inch	2 inch

SUMMARY

Corn injury at the first and second evaluation date were greater than corn injury at the final evaluation date which was timed to flowering stage (Table 2). Treatments containing Sharpen or Widematch tended to give more corn injury than the PRE Harness + atrazine followed by (fb) Status. Two applications of Widematch + Status + Roundup PowerMax tended to give the most injury in the experiment. Injury tended to be negligible by the final evaluation.

Redroot pigweed, lambsquarters and kochia were present across the experiment. Redroot pigweed and lambsquarters pressure was heavy and uniform while kochia pressure was light and uneven. Redroot pigweed control was similar from treatments that included PRE herbicides compared to entries that were POST applications only (Table 2). Two applications of Widematch + Status + Roundup PowerMax gave near perfect redroot pigweed control. Preemergence Sharpen fb Widematch gave 84% pigweed control on August 4 and was the only treatment that gave less than 91% redroot pigweed control.

Table 2. Corn injury and common lambsquarters, kochia, and redroot pigweed control at Barney, ND in 2015.

Treatment	Rate	Appl Code	corn Jun 24	corn Jul 7	corn Aug 4	colq[4] Jul 7	colq[4] Aug 4	kocz Jul 7	kocz Aug 4	rrpw Jul 7	rrpw Aug 4
			------% injury------			--------------------% control--------------------					
Harness+Sharpen	2 pt+3 fl oz	A	3	6	0	74	81	91	94	94	93
Harness+Clarity / Widematch[1]	2 pt+1 pt / 1.3 pt	A/ B	15	13	0	86	86	100	100	91	93
Harness+ Aatrex / Status[2]	2 pt+12 fl oz / 7.5 oz	A/ B	0	0	0	90	94	100	100	94	98
Harness / Status[2]	2 pt / 10 oz	A/ B	0	8	5	90	92	100	100	90	94
Harness / Widematch[1]	2 pt / 1.3 pt	A/ B	4	3	0	75	81	100	100	89	94
Harness / Buctril	2 pt / 1.5 pt	A/ B	0	0	0	81	69	85	94	94	94
Sharpen / Status+Warrant+RUPMax[3]	3 fl oz / 5oz+3pt+28 floz	A/ B	8	16	5	91	94	100	100	99	97
Sharpen / Status[2]	3 pt / 7.5 oz	A/ B	15	18	5	88	91	100	100	78	93
Sharpen / Widematch[1]	3 fl oz / 1.3 pt	A/ B	15	14	10	84	89	98	100	66	84
Laudis+Aatrex[2]	3 fl oz+ 12 fl oz	B	0	0	0	86	94	95	100	88	95
RU PowerMax+Status[3]	28 fl oz+10oz	B	6	13	3	91	93	100	100	88	91
Wdmatch+Status+RUPMax[3]/ Wdmatch+Status+RUPMax[3]	1pt+5oz+28 floz/ 1pt+5oz+28 floz	B/ C	9	23	8	100	100	100	100	100	100
LSD (0.10)			**8**	**6**	**6**	**4**	**14**	**6**	**4**	**6**	**4**

[1]Applied with nonionic surfactant (NIS) at 0.25% v/v
[2]Applied with methylated seed oil (MSO) at 1.5 pt/A
[3]Applied with high surfactant methylated oil concentrate (HSMOC) at 1.5 pt/A
[4]colq=common lambsquarters; kocz=kochia; rrpw=redroot pigweed

The kochia infestation was light because the initial flush was removed with tillage. Consequently, kochia control was near 100% from treatments that contained POST applications of Widematch, Status, or Laudis (Table 2). Preemergence Harness + Sharpen (no POST) and PRE Harness fb Buctril gave 94% kochia control on August 4 which was less than any other treatments.

Lambsquarters pressure was heavy throughout the experiment. Two applications of Widematch + Status + Roundup PowerMax gave the greatest lambsquarters control in the experiment at 100% (Table 2). The data suggests Status and Laudis may provide greater lambsquarters control than Widematch. Preemergence Harness + Sharpen, PRE Harness fb Widematch, and PRE Harness fb Buctril gave less lambsquarters control than two applications of Widematch + Status + Roundup PowerMax.

Farmers should use a chloroacetamide herbicide when trying to control tough weeds in corn as part of a sugarbeet containing rotation. The question is timing. The logical timing is PRE. However, Warrant applied lay-by was safe on corn and provided season-long waterhemp control in other experiments at Herman and Moorhead and, in a systems approach, controlled other grass and broadleaf weeds. Controlling weeds in corn with herbicides other than glyphosate is important to maintain the longevity of glyphosate in sugarbeet.

WATERHEMP CONTROL IN CORN – MOORHEAD, MN

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The objective of this experiment was to demonstrate a systems approach for controlling waterhemp in corn using herbicides that allow sugarbeet to be grown the next season while using herbicide sites of action that differ from glyphosate.

MATERIALS AND METHODS

An experiment was conducted on natural waterhemp populations near Moorhead, MN in 2015. The field site was cultivated with a Kongskilde 's-tine' field cultivator on April 28, 2015. 'DKC38-04RIB' RR corn was seeded in 22-inch rows at 34,600 seeds per acre on April 30. 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 30-feet in length. Preemergence (PRE) treatments were applied May 1, one day following planting (Table 1). Postemergence (POST) treatments were applied June 12 and June 21. Corn injury was evaluated on June 11 and 29 and August 5 while weed control was evaluated August 5 and 20. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A	B	C
Date	1 May	12 June	21 June
Time of Day	1:30 PM	10:00 AM	6:00 PM
Air Temperature (F)	75	76	70
Relative Humidity (%)	28	43	58
Wind Velocity (mph)	3	4	6
Wind Direction	NW	SW	ENE
Soil Temp. (F at 6")	60	64	74
Soil Moisture	Slightly Wet	Slightly Dry	Dry
Cloud Cover (%)	10	0	40
Corn stage (avg)	PRE	V6	V8
Waterhemp	-	1.5 inch	1 inch
Common Lambsquarters	-	5 inch	1.5 inch

SUMMARY

Corn injury generally was negligible in this experiment (Table 2.) No significant differences were observed among any treatments.

There were very low infestations of barnyardgrass and biennial wormwood in this experiment. In general, barnyardgrass control was very similar across all treatments at 99 to 100%. However, barnyardgrass control from PRE Sharpen followed by (fb) Status was only 95%. Status does not provide good grass control. Biennial wormwood control was perfect or near perfect from all treatments.

Lambsquarters was present in the experiment and was generally uniformly distributed across the experiment. Lambsquarters control was very good from most treatments and ranged from 89 to 100% when a PRE herbicide was followed by a POST. A single application of Laudis + AAtrex or Roundup PowerMax + Status gave 98 and 95% lambsquarters control, respectively. Two POST applications (Laudis + AAtrex fb Roundup PowerMax + Status) gave 100% lambsquarters control. Preemergence Harness + Sharpen (with no POST) gave only 10% control of lambsquarters in this experiment. Sharpen provides only fair control of lambsquarters and precipitation for activating Harness did not arrive until two weeks after application. It is possible the poor control from PRE Harness + Sharpen is from lambsquarters that germinated and emerged before the acetochlor (Harness) was activated.

Table 2. Corn injury and common lambsquarters and waterhemp control at Moorhead, MN in 2015.

Treatment	Rate	Appl Code	corn Jun 11	corn Jun 29	corn Aug 5	colq[3] Aug 5	colq[3] Aug 20	wahe Aug 5	wahe Aug 20
			--------% injury--------			-----------% control------------			
Harness+Sharpen	2 pt+3 fl oz	A	0	5	5	13	10	74	75
Harness+Clarity / Laudis+AAtrex[1]	2 pt+1 pt / 3+12 fl oz	A/ B	3	5	5	100	100	98	97
Harness+ AAtrex / Status[1]	2 pt+12 fl oz / 7.5 oz	A/ B	0	0	4	98	93	88	83
Harness / Status[1]	2 pt / 10 oz	A/ B	5	3	0	94	89	91	86
Harness / Laudis+AAtrex[1]	2 pt / 3+12 fl oz	A/ B	3	4	3	100	90	100	99
Sharpen / Status[1]	3 fl oz / 7.5 oz	A/ B	0	5	0	94	94	90	91
Sharpen / Laudis+AAtrex[1]	3 fl oz / 3+12 fl oz	A/ B	0	6	4	100	100	99	100
Sharpen / Status+Warrant+RUPMax[2]	3 fl oz / 5oz+3pt+28 floz	A/ B	3	9	3	100	98	99	96
Laudis+AAtrex[1]	3+12 fl oz	B	0	0	4	100	98	99	98
RU PowerMax+Status[2]	32 fl oz+10oz	B	0	4	3	100	95	92	86
Laudis+AAtrex[1] / Status+RUPMax[2]	3+12 fl oz / 5oz+28 floz	B/ C	0	5	8	100	100	99	98
LSD (0.10)			**NS**	**NS**	**NS**	**4**	**10**	**5**	**7**

[1]Applied with ammonium sulfate (AMS) at 8.5 lb/100 gal + methylated seed oil (MSO) at 1.5 pt/A
[2]Applied with AMS at 8.5 lb/100gal + high surfactant methylated oil concentrate (HSMOC) at 1.5 pt/A
[3]colq=common lambsquarters; wahe=waterhemp

Waterhemp control was dependent on herbicide and application timing in this experiment. Waterhemp control was generally the most consistent from PRE herbicides followed by POST herbicides. Waterhemp control was greatest from treatments containing Laudis + atrazine and ranged from 97 to 100%. Treatments containing Status gave 83 to 96% waterhemp control which tended to be less control than from those treatments containing Laudis + atrazine. Preemergence Harness + Sharpen did not provide season-long control of waterhemp with only 75% control on August 20. Corn was planted early at this location and waterhemp did not emerge until approximately 4 to 5 weeks after PRE herbicides were applied. This time frame may have allowed for some degradation in soil herbicides and consequentially, reduced activity. Heavy, fine textured soils that were consistently wet throughout a cool May may have slowed corn growth. Waterhemp may have been able to take advantage of these conditions which allowed for sub-optimal control from some treatments that gave excellent control at the Herman location. Possible consideration for a lay-by treatment under these conditions in the future.

WATERHEMP CONTROL IN CORN – HERMAN, MN

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The objective of this experiment was to demonstrate a systems approach for controlling waterhemp in corn using herbicides that allow sugarbeet to be grown the next season while using herbicide sites of action that differ from glyphosate.

MATERIALS AND METHODS

An experiment was conducted on natural waterhemp populations near Herman, MN in 2015. The field site was fertilized then cultivated with a field cultivator on June 2, 2015. 'DKC38-04RIB' RR corn was seeded in 22-inch rows at 34,600 seeds per acre on June 2. 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 30-feet in length. Preemergence (PRE) treatments were applied June 4, two days following planting (Table 1). Postemergence (POST) treatments were applied June 24 and July 7. Corn injury was evaluated on July 6, 17, and 31 while weed control was evaluated July 31 and September 9. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A	B	C
Date	4 June	24 June	7 July
Time of Day	5:00 PM	5:00 PM	11:30 AM
Air Temperature (F)	72	83	68
Relative Humidity (%)	55	40	43
Wind Velocity (mph)	4	5	4
Wind Direction	SE	SW	SE
Soil Temp. (F at 6")	63	76	66
Soil Moisture	Slightly Dry	Slightly Wet	Dry
Cloud Cover (%)	95	80	5
Corn stage (avg)	PRE	V4	V8
Waterhemp	-	3 inch	11 inch
Common Lambsquarters	-	1.5 inch	4 inch

SUMMARY

Corn injury was observed in the experiment but was generally not dependent on herbicide entry. PRE Sharpen followed by (fb) Status gave 14% visual injury averaged across evaluations and Roundup PowerMax + Status gave 12% injury (Table 2). It is unclear why these treatments showed injury while other treatments containing Status did not. No significant difference in corn injury was observed among treatments by July 31.

A light infestation of foxtail species was present in the experiment. Foxtail control tended to be perfect across entries in the experiment (data available upon request). Lambsquarters control also was near perfect with all treatments giving 99 to 100% control at the September 9 evaluation.

Waterhemp populations were quite dense and uniform in this study and control, generally, was very good. Control ranged from 80% to 100% control across entries and application timings on September 9 (Table 2). Treatments containing PRE followed by POST herbicides provided 98 to 100% waterhemp control. Preemergence Harness + Sharpen with no POST applications gave 95% waterhemp control. A single POST application of Roundup PowerMax + Status gave 80% control and a single application of Laudis + AAtrex gave 93% control. Two POST applications (Laudis + AAtrex fb Status + Roundup PowerMax) gave 100% waterhemp control. Using a PRE herbicide from site of action (SOA) 14 or 15 fb Status (SOA 4, 19) or Laudis + atrazine (SOA 27+5) appears to be an excellent option for controlling glyphosate-resistant waterhemp in corn as part of a sugarbeet containing rotation.

Table 2. Corn injury and common lambsquarters and waterhemp control at Herman, MN in 2015.

Treatment	Rate	Appl Code	corn			colq[3]		wahe	
			Jul 6	Jul 17	Jul 31	Jul 31	Sep 9	Jul 31	Sep 9
			--------% injury--------			-----------% control-----------			
Harness+Sharpen	2 pt+3 fl oz	A	4	10	9	98	99	96	95
Harness+Clarity / Laudis+AAtrex[1]	2 pt+1 pt / 3+12 fl oz	A/ B	14	8	3	100	100	99	99
Harness+ AAtrex / Status[1]	2 pt+12 fl oz / 7.5 oz	A/ B	9	0	6	100	100	98	100
Harness / Status[1]	2 pt / 10 oz	A/ B	9	4	8	100	100	100	99
Harness / Laudis+AAtrex[1]	2 pt / 3+12 fl oz	A/ B	0	4	5	100	100	99	100
Sharpen / Status[1]	3 fl oz / 7.5 oz	A/ B	15	18	8	100	100	100	100
Sharpen / Laudis+AAtrex[1]	3 fl oz / 3+12 fl oz	A/ B	4	6	8	100	100	100	98
Sharpen / Status+Warrant+RUPMax[2]	3 fl oz / 5oz+3pt+28 floz	A/ B	5	5	5	100	100	100	100
Laudis+AAtrex[1]	3+12 fl oz	B	0	0	5	100	100	98	93
RU PowerMax+Status[2]	32 fl oz+10oz	B	10	16	11	100	100	86	80
Laudis+AAtrex[1] / Status+RUPMax[2]	3+12 fl oz / 5oz+28 floz	B/ C	4	3	6	100	100	100	100
LSD (0.10)			**9**	**10**	**NS**	**NS**	**NS**	**5**	**5**

[1]Applied with ammonium sulfate (AMS) at 8.5 lb/100 gal + methylated seed oil (MSO) at 1.5 pt/A

[2]Applied with AMS at 8.5 lb/100gal + high surfactant methylated oil concentrate (HSMOC) at 1.5 pt/A

[3]colq=common lambsquarters; wahe=waterhemp

KOCHIA CONTROL IN SOYBEAN – BARNEY, ND

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The objective of this experiment was to demonstrate a systems approach for controlling kochia in soybean using herbicides with herbicide sites of action that differ from glyphosate and allow sugarbeet to be grown within two years of application.

MATERIALS AND METHODS

An experiment was conducted on natural kochia populations near Barney, ND in 2015. The field site was cultivated twice with a Kongskilde 's-tine' field cultivator on May 21, 2015. Peterson Farm Seed 'L05-11N' soybeans were seeded in 22-inch rows at 144,500 seeds per acre on May 21. 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 30-feet in length. Preplant incorporated (PPI) treatments were incorporated immediately following application using a rototiller set 2 to3 inches deep (Table 1). Preemergence (PRE) treatments were applied following planting. Postemergence (POST) treatments were applied June 15 and June 29. Soybean injury was evaluated on June 29, July 15, and August 4 while weed control was evaluated July 7 and August 4. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A & B	C	D
Date	21 May	15 June	29 June
Time of Day	1:15 PM	11:30 AM	12:30 PM
Air Temperature (F)	66	70	77
Relative Humidity (%)	29	47	63
Wind Velocity (mph)	3	9	4
Wind Direction	NW	N	N
Soil Temp. (F at 6")	56	65	68
Soil Moisture	Slightly Wet	Slightly Dry	Slightly Wet
Cloud Cover (%)	0	10	100
Soybean stage (avg)	PPI & PRE	V4	V5
Kochia	-	5 inch	12 inch
Redroot Pigweed	-	3 inch	0.75 inch
Common Lambsquarters	-	9 inch	3 inch

SUMMARY

There was a planter skip in the experiment that influenced soybean stand and weed control. Soybean injury was influenced by herbicide. Soybean injury was greatest from treatments containing Cadet (Table 2). Treatments containing only Basagran or Liberty as the POST herbicide, generally gave negligible crop injury. Some late season growth reduction from PRE Dual Magnum + Demetric followed by (fb) Liberty was observed, but the reason for this injury is unclear.

Barnyardgrass was evaluated and in general, most entries gave very good barnyardgrass control at 94 to 100% (data available upon request). However, barnyardgrass control from two applications of Basagran + Cadet or PRE Verdict fb Basagran was 90% which tended to be less than from other treatments.

Table 2. Soybean injury and common lambsquarters, kochia, and redroot pigweed control at Barney, ND in 2015.

		Appl	soybean			colq[3]		kocz		rrpw	
Treatment	Rate	Code	Jun 29	Jul 15	Aug 4	Jul 7	Aug 4	Jul 7	Aug 4	Jul 7	Aug 4
			------% injury------			-------------------% control-------------------					
Treflan+Valor SX / Liberty[1]	1.5 pt+3 oz / 29 fl oz	A/ C	0	0	3	85	83	91	95	81	91
Dual Magnum+Valor SX / Liberty[1]	2 pt+3 oz / 29 fl oz	B/ C	3	3	9	93	86	96	98	96	95
Dual Magnum+Dimetric / Liberty[1]	2 pt+5.3 oz / 29 fl oz	B/ C	3	8	13	81	66	95	98	88	85
Sharpen+Valor SX / Liberty[1]	1 fl oz+3 oz / 29 fl oz	B/ C	4	3	5	91	89	98	98	91	98
Verdict+Valor SX / Liberty[1]	5 fl oz+3 oz / 29 fl oz	B/ C	0	0	3	94	89	100	100	93	100
Outlook+Verdct+Valor SX / Liberty[1]	14floz+5floz+3oz / 29 fl oz	B/ C	8	5	5	93	87	100	98	93	98
Valor SX / Cadet[2] / Cadet[2]	3 oz / 0.7 fl oz / 0.7 fl oz	B/ C / D	5	15	8	89	80	100	100	91	94
Verdict / Basagran[2] / Basagran[2]	5 fl oz / 1 pt / 1 pt	B/ C / D	0	0	0	74	59	100	100	94	96
Sharpen+Warrant / Basagran[2] / Basagran[2]	1 fl oz+3pt / 1 pt / 1 pt	B/ C / D	8	0	6	86	70	96	98	95	100
Basagran+Cadet[2] / Basagran+Cadet[2]	1 pt+0.7 fl oz/ 1 pt+0.7 fl oz	C/ D	33	23	10	83	64	100	98	84	79
Liberty[1] / Liberty[1]	29 fl oz / 29 fl oz	C/ D	5	3	5	86	88	100	100	89	98
LSD (0.10)			**7**	**10**	**6**	**7**	**14**	**5**	**NS**	**6**	**9**

[1]Applied with ammonium sulfate (N-Pak AMS) at 8.5 lb/100 gal
[2]Applied with methylated seed oil (MSO) at 1.5 pt/A
[3]colq=common lambsquarters; kocz=kochia; rrpw=redroot pigweed

Redroot pigweed and common lambsquarters populations were dense and uniform while the infestation of kochia was light and tended to be variable. There was one flush of kochia at this location. Unfortunately, the majority of that flush was controlled with tillage. This led to excellent kochia control in the experiment. All treatments provided greater than 95% kochia control at the Aug 4 evaluation with most treatments providing at least 98% control (Table 2).

Redroot pigweed control was dependent on herbicide treatment and application timing. Pigweed control from two applications of Basagran + Cadet was 78% on August 4 which was less than control from any other treatment. Treatments containing a soil-applied herbicide gave 91% or greater pigweed control on August 4 with the exception of PRE Dual Magnum + Dimetric fb Liberty which gave only 85% control. Liberty followed many of the soil-applied entries and was sprayed when pigweed was 3 inches or less. Pigweed was slow to die when treated with Liberty. Air temperature was 70° F and relatively humidity was 47% at application which may explain the delayed or reduced pigweed control.

Lambsquarters control was dependent on herbicide treatment. There were no herbicide treatments that provided greater than 90% lambsquarters control at the August 4 evaluation. In general, herbicide treatments containing Liberty provided greater lambsquarters control than treatments containing Cadet or Basagran. PRE Dual Magnum + Dimetric fb Liberty provided only 66% lambsquarters control which was less control than any other PRE fb Liberty combination.

This experiment illustrates the importance of environmental conditions at application for maximizing efficacy from Liberty. To maximize efficacy from Liberty (a contact herbicide), applications should be made no closer than 2 hours before sunset, applications should be made when temperatures are hot and humid and skies are mostly sunny, AMS at 3 lb/A or greater should be used, and spray volumes should exceed 15 gallons per acre. Refer to paragraph B9 on page 77 of the 2015 North Dakota Weed Control Guide for more information on applying Liberty (www.ag.ndsu.edu/weeds/weed-control-guides/nd-weed-control-guide-1/wcg-files/12-TextCrop.pdf).

With the exception of Dimetric (metribuzin), all herbicides in this experiment allow for rotation to sugarbeet the following season. Liberty Link technology provides an excellent tool to help control tough weeds in the soybean year of a sugarbeet containing rotation. However, repeated use of an herbicide with a single mode of action will increase the likelihood of selecting for weeds with resistance to that mode of action. Using a PRE herbicide from site of action (SOA) 14 and/or SOA15 followed by Liberty (SOA 10) appears to be an excellent option for controlling tough weeds in soybean as part of the sugarbeet rotation.

WATERHEMP CONTROL IN SOYBEAN – MOORHEAD, MN

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The objective of this experiment was to demonstrate a systems approach for controlling waterhemp in soybean using herbicides with sites of action that differ from glyphosate.

MATERIALS AND METHODS

An experiment was conducted on waterhemp near Moorhead, MN in 2015. The field site was cultivated with a Kongskilde 's-tine' field cultivator on June 10, 2015. Peterson Farm Seed 'L05-11N' soybeans were seeded in 22-inch rows at 144,500 seeds per acre on June 11. 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 30-feet in length. Preplant incorporated (PPI) treatments were incorporated immediately following application using a rototiller set 2 to 3 inches deep (Table 1). Preemergence (PRE) treatments were applied following planting. Postemergence (POST) treatments were applied July 10 and 21. Soybean injury was evaluated on July 9 and 24 and August 20 while weed control was evaluated July 24 and August 20. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A & B	C	D
Date	11 June	10 July	21 July
Time of Day	9:30 AM	8:30 AM	10:00 AM
Air Temperature (F)	73	70	74
Relative Humidity (%)	45	50	54
Wind Velocity (mph)	2	3	3
Wind Direction	E	SE	NE
Soil Temp. (F at 6")	62	64	70
Soil Moisture	Slightly Wet	Slightly Dry	Slightly Dry
Cloud Cover (%)	5	0	3
Soybean stage (avg)	PRE	V4	V7-R1
Waterhemp	-	10 inch	17 inch

SUMMARY

The experiment had some areas of extreme iron chlorosis and excess moisture. There was soybean injury in the experiment and injury was most pronounced at the July 24 evaluation timing (Table 2). Injury was greatest from treatments containing Cadet. Injury was also significant over time and consistent from PRE Dual Magnum + Valor followed by (fb) Liberty, PRE Dual Magnum + Dimetric fb Liberty, and PRE Outlook + Verdict + Valor fb Liberty.

Common purslane and barnyardgrass were minor weeds in the experimental area that were evaluated (data available upon request). Purslane control on July 24 was near prefect from many treatments containing soil applied herbicides fb Liberty. Control was less from Cadet or Basagran (86-91%), however, the combination of Cadet and Basagran provided 100% purslane control. Barnyardgrass control generally was near perfect. The least control (93-96%) was from treatments containing Cadet or Basagran and PRE Sharpen + Warrant fb Basagran.

Table 2. Soybean injury and common lambsquarters and waterhemp control at Moorhead, MN in 2015.

Treatment	Rate	Appl Code	soybean Jul 9	soybean Jul 24	soybean Aug 20	colq[3] Jul 24	colq[3] Aug 20	wahe Jul 24	wahe Aug 20
			--------% injury--------			-----------% control-----------			
Treflan+Valor SX / Liberty[1]	1.5 pt+3 oz / 29 fl oz	A/ C	3	18	13	98	94	94	93
Dual Magnum+Valor SX / Liberty[1]	2 pt+3 oz / 29 fl oz	B/ C	15	18	15	97	98	100	99
Dual Magnum+Dimetric / Liberty[1]	2 pt+5.3 oz / 29 fl oz	B/ C	8	16	14	94	91	96	85
Sharpen+Valor SX / Liberty[1]	1 fl oz+3 oz / 29 fl oz	B/ C	3	8	10	96	91	99	98
Verdict+Valor SX / Liberty[1]	5 fl oz+3 oz / 29 fl oz	B/ C	0	5	9	99	100	99	100
Outlook+Verdict+Valor SX / Liberty[1]	14floz+5floz+3oz / 29 fl oz	B/ C	10	19	16	99	96	100	100
Valor SX / Cadet[2] / Cadet[2]	3 oz / 0.7 fl oz / 0.7 fl oz	B/ C / D	0	28	18	100	100	84	71
Verdict / Basagran[2] / Basagran[2]	5 fl oz / 1 pt / 1 pt	B/ C / D	5	20	9	95	94	64	65
Sharpen+Warrant / Basagran[2] / Basagran[2]	1 fl oz+3pt / 1 pt / 1 pt	B/ C / D	0	13	11	89	90	68	63
Basagran+Cadet[2] / Basagran+Cadet[2]	0.5 pt+0.7 fl oz/ 0.5 pt+0.7 fl oz	C/ D	0	26	16	90	96	76	51
Liberty[1] / Liberty[1]	29 fl oz / 29 fl oz	C/ D	0	14	14	98	100	95	100
LSD (0.10)			**9**	**10**	**NS**	**NS**	**NS**	**7**	**8**

[1]Applied with ammonium sulfate (N-Pak AMS) at 8.5 lb/100 gal
[2]Applied with methylated seed oil (MSO) at 1.5 pt/A
[3]colq=common lambsquarters; wahe=waterhemp

Common lambsquarters was an important weed in this experiment. All treatments generally provided very similar and consistent lambsquarters control and there were no significant differences among treatments (Table 2). However, PRE Dual Magnum + Dimetric fb Liberty, PRE Sharpen + Valor SX fb Liberty and PRE Sharpen + Warrant fb Basagran tended to give less lambsquarters control as the season progressed.

Waterhemp control was affected by herbicides and timing of application. Treatments that contained Cadet or Basagran provided only 51 to 71% waterhemp control (Table 2). Waterhemp control on August 20 was greater than 98% from all treatments containing a PRE and fb Liberty with the exception of PPI Treflan + Valor SX fb Liberty (93% control) and PRE Dual Magnum + Dimetric fb Liberty (85% control). Preemergence Outlook + Verdict + Valor fb Liberty, PRE Dual Magnum + Valor fb Liberty, and Liberty fb Liberty 99 to 100% control and gave the greatest waterhemp control (95-98%) at the Herman location.

To maximize efficacy from Liberty (a contact herbicide), applications should be made no closer than 2 hours before sunset, applications should be made when temperatures are hot and humid and skies are mostly sunny, AMS at 3 lb/A or greater should be used, and spray volumes should exceed 15 gallons per acre. Refer to paragraph B9 on page 77 of the 2015 North Dakota Weed Control Guide for more information on applying Liberty (www.ag.ndsu.edu/weeds/weed-control-guides/nd-weed-control-guide-1/wcg-files/12-TextCrop.pdf).

With the exception of Dimetric (metribuzin), all herbicides in this experiment allow for rotation to sugarbeet the following season. Liberty Link technology provides an excellent tool to help control waterhemp in the soybean year of a sugarbeet containing rotation. However, repeated use of an herbicide with a single mode of action will increase the likelihood of selecting for weeds with resistance to that mode of action. Using a PRE herbicide from site of action (SOA) 14 and/or SOA15 followed by Liberty (SOA 10) appears to be the best option for controlling glyphosate-resistant waterhemp in soybean as part of the sugarbeet rotation.

WATERHEMP CONTROL IN SOYBEAN – HERMAN, MN

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The objective of this experiment was to demonstrate a systems approach for controlling waterhemp in soybean using herbicides with sites of action that differ from glyphosate.

MATERIALS AND METHODS

An experiment was conducted on natural waterhemp populations near Herman, MN in 2015. The field site was fertilized then cultivated with a field cultivator on June 2, 2015. Peterson Farm Seed 'L05-11N' soybeans were seeded in 22-inch rows at 144,500 seeds per acre on June 4. 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 30-feet in length. Preplant incorporated (PPI) treatments were incorporated immediately following application using a rototiller set 2 to 3 inches deep (Table 1). Preemergence (PRE) treatments were applied following planting. Postemergence (POST) treatments were applied June 24 and July 7. Soybean injury was evaluated on July 6, 17, and 31 while weed control was evaluated July 17 and September 9. All evaluations were a visual estimate of percent fresh weight reduction in the center four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Environmental Conditions at Time of Application

Application Code	A & B	C	D
Date	4 June	24 June	7 July
Time of Day	4:00 PM	5:30 PM	11:00 AM
Air Temperature (F)	72	83	68
Relative Humidity (%)	55	40	43
Wind Velocity (mph)	4	5	4
Wind Direction	SE	SW	SE
Soil Temp. (F at 6")	63	76	66
Soil Moisture	Slightly Dry	Slightly Wet	Dry
Cloud Cover (%)	98	80	5
Soybean stage (avg)	PPI & PRE	V2	V4
Waterhemp	-	3 inch	11 inch
Common Lambsquarters	-	1.5 inch	4 inch

SUMMARY

The experiment was very uniform with soybean stands being near perfect across the study. Soybean injury was generally negligible except from Cadet, either applied alone or in a mixture with Basagran (Table 2). Neither the soil applied herbicides nor Liberty seemed to cause any visual soybean injury.

In general, lambsquarters control was very good with all treatments providing greater than 90% lambsquarters control (Table 2). Verdict + Valor followed by (fb) Liberty gave the least numerical lambsquarters control at 94% on September 9. However, there were no statistical differences in common lambsquarters control among treatments.

There was a light infestation of green foxtail in the experiment. In general, foxtail control was very good (data available upon request). However, control was less or tended to be less with treatments that contained Cadet.

Waterhemp control was dependent on herbicide and application timing. Treatments containing a PRE herbicide fb Liberty gave greater waterhemp control than a PRE herbicide fb Basagran. Two POST applications of Basagran + Cadet provided only 63% waterhemp control by September 9. To maximize efficacy, Basagran and Cadet should be applied to very small (<2") weeds. Waterhemp was 3" tall at the first POST application. While poor waterhemp control from Basagran and Cadet in this experiment may be partially due to spraying large waterhemp, this illustrates the importance of spraying very small weeds with these herbicides. All treatments containing Liberty, with the exception of PRE Verdict + Valor gave greater than 80% waterhemp control on September 9.

Table 2. Soybean injury and common lambsquarters and waterhemp control at Herman, MN in 2015.

Treatment	Rate	Appl Code	soybean Jul 6	soybean Jul 17	soybean Jul 31	colq[3] Jul 17	colq[3] Sep 9	wahe Jul 17	wahe Sep 9
			--------% injury--------			-----------% control------------			
Treflan+Valor SX / Liberty[1]	1.5 pt+3 oz / 29 fl oz	A/ C	0	0	0	99	99	88	84
Dual Magnum+Valor SX / Liberty[1]	2 pt+3 oz / 29 fl oz	B/ C	3	5	0	98	96	98	96
Dual Magnum+Dimetric / Liberty[1]	2 pt+5.3 oz / 29 fl oz	B/ C	4	5	6	95	98	86	82
Sharpen+Valor SX / Liberty[1]	1 fl oz+3 oz / 29 fl oz	B/ C	3	0	0	99	100	90	84
Verdict+Valor SX / Liberty[1]	5 fl oz+3 oz / 29 fl oz	B/ C	0	3	3	93	94	89	78
Outlook+Verdict+Valor SX / Liberty[1]	14floz+5floz+3oz / 29 fl oz	B/ C	5	3	6	100	100	98	95
Valor SX / Cadet[2] / Cadet[2]	3 oz / 0.7 fl oz / 0.7 fl oz	B/ C / D	10	20	19	96	98	94	81
Verdict / Basagran[2] / Basagran[2]	5 fl oz / 1 pt / 1 pt	B/ C / D	0	3	0	100	100	66	20
Sharpen+Warrant / Basagran[2] / Basagran[2]	1 fl oz+3pt / 1 pt / 1 pt	B/ C / D	3	6	5	96	98	76	58
Basagran+Cadet[2] / Basagran+Cadet[2]	0.5 pt+0.7 fl oz/ 0.5 pt+0.7 fl oz	C/ D	16	33	28	94	100	85	63
Liberty[1] / Liberty[1]	29 fl oz / 29 fl oz	C/ D	1	5	0	100	100	91	98
LSD (0.10)			**6**	**4**	**6**	**NS**	**NS**	**5**	**10**

[1]Applied with ammonium sulfate (N-Pak AMS) at 8.5 lb/100 gal
[2]Applied with methylated seed oil (MSO) at 1.5 pt/A
[3]colq=common lambsquarters; wahe=waterhemp

Three treatments gave excellent waterhemp control. Preemergence Outlook + Verdict + Valor fb Liberty gave 95% control, PRE Dual Magnum + Valor fb Liberty gave 96% control and Liberty fb Liberty gave 98% control on September 9 (Table 2). These treatments also gave 99 to 100% waterhemp control at the Moorhead location. To maximize efficacy from Liberty (a contact herbicide), applications should be made no closer than 2 hours before sunset, applications should be made when temperatures are hot and humid and skies are mostly sunny, AMS at 3 lb/A or greater should be used, and spray volumes should exceed 15 gallons per acre. Refer to paragraph B9 on page 77 of the 2015 North Dakota Weed Control Guide for more information on applying Liberty (www.ag.ndsu.edu/weeds/weed-control-guides/nd-weed-control-guide-1/wcg-files/12-TextCrop.pdf).

With the exception of Dimetric (metribuzin), all herbicides in this experiment allow for rotation to sugarbeet the following season. Liberty Link technology provides an excellent tool to help control waterhemp in the soybean year of a sugarbeet containing rotation. However, repeated use of an herbicide with a single mode of action will increase the likelihood of selecting for weeds with resistance to that mode of action. Using a PRE herbicide from site of action (SOA) 14 and/or SOA15 followed by Liberty (SOA 10) appears to be the best option for controlling glyphosate-resistant waterhemp in soybean as part of the sugarbeet rotation.

SUGARBEET INJURY AND WEED CONTROL FROM NANO-REVOLUTION 2.0 APPLIED WITH GLYPHOSATE IN 2015

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The objective of this study was to evaluate Nano-Revolution 2.0 applied with glyphosate on common lambsquarter and glyphosate-resistant kochia and waterhemp control in Roundup Ready (RR) sugarbeet.

MATERIALS AND METHODS

'HM4022RR' sugarbeet was seeded in 22-inch rows at 60,560 seeds per acre on April 23 at Barney, ND. Herbicide treatments were applied postemergence (POST) in sugarbeet on June 10 with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 psi to the center four rows of six row plots 30 feet in length. Weed control was evaluated June 19.

'SV36271RR' sugarbeet was seeded in 22-inch rows at 60,560 seeds per acre on April 30 at Moorhead, MN. Herbicide treatments were applied POST in sugarbeet on June 11 with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 psi to the center four rows of six row plots 30 feet in length. Weed control was evaluated June 21.

Peterson Farm Seed 'L05-11N' soybeans were seeded in 22-inch rows at 144,000 seeds per acre on May 21 at Barney, ND. Herbicide treatments were applied POST in sugarbeet on June 29 with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 psi to the center four rows of six row plots 30 feet in length. Weed control was evaluated July 7.

All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications for each trial. Data from each experiment were analyzed independently with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Application Information

Experiment	Barney Sugarbeet	Moorhead Sugarbeet	Barney Soybean
Date	10 June	11 June	29 June
Time of Day	11:00 AM	2:00 PM	
Air Temperature (F)	69	77	77
Relative Humidity (%)	52	40	63
Wind Velocity (mph)	7	5	4
Wind Direction	NE	E	N
Soil Temp. (F at 6")	66	70	68
Soil Moisture	Dry	Slightly Wet	Good
Cloud Cover	70	15	
Crop stage (avg)	4 leaf	6 leaf	V4
Kochia stage	10 inch	-	20 inch
Common Lambsquarters	20 inch	8 inch	26 inch
Waterhemp	-	2 inch	-

SUMMARY

Barney Sugarbeet Experiment – Kochia populations were variable across the study. No statistical differences were observed among treatments for kochia control or lambsquarters control (Table 2). However, the addition of Prefer 90 NIS plus N Pak AMS, or Nano-Revolution 2.0 to Roundup PowerMax at 22 fl oz/A tended to improve kochia and lambsquarters control compared to Roundup PowerMax alone. Control of glyphosate resistant kochia ranged from 13 to 23% and was not commercially acceptable from any treatment. Common lambsquarters control was fair from all treatments.

Moorhead Sugarbeet Experiment – Waterhemp and lambsquarters populations were very uniform across the study. No statistical differences were observed among treatments for waterhemp or lambsquarters control (Table 2). However, the addition of Prefer 90 NIS, Prefer 90 NIS plus N Pak AMS, or Nano-Revolution 2.0 to Roundup PowerMax at 22 fl oz/A tended to improve waterhemp control compared to Roundup PowerMax alone. Control of glyphosate resistant waterhemp ranged from 35 to 45% and was not commercially acceptable from any treatment. Common lambsquarters control was excellent from all treatments.

Barney Soybean Experiment - Lambsquarters populations were heavy and uniform, while kochia populations were more variable across the study. No statistical differences were observed among treatments for kochia or lambsquarters control (Table 2). However, the addition of Prefer 90 NIS, Prefer 90 NIS plus N Pak AMS, or Nano-Revolution 2.0 to Roundup PowerMax at 22 fl oz/A tended to improve kochia control compared to Roundup PowerMax alone. Control of glyphosate resistant kochia ranged from 20 to 33% and was not commercially acceptable from any treatment. Common lambsquarters control was good from all treatments.

CONCLUSION

Nano-Revolution 2.0 does not control glyphosate resistant waterhemp or kochia. When applied at 2 to 4 fl oz per acre with glyphosate, Nano-Revolution 2.0 appears to be similar to NIS or AMS+NIS at enhancing glyphosate efficacy compared to applying glyphosate alone.

Table 2. Weed control from glyphosate plus Nano-Revolution 2.0 or other adjuvants in three experiments in 2015.

		Barney sugarbeet		Moorhead sugarbeet		Barney soybean	
		------19 Jun------		------21 Jun------		------7 Jul------	
Treatment	Rate	kocz cntl	colq cntl	wahe cntl	colq cntl	kocz cntl	colq cntl
		----------------	--------	%	--------	----------------	
RU PowerMax	22 fl oz/a	17	77	36	98	20	95
RU PowerMax + Prefer 90 NIS	22 fl oz/a + 0.25 % v/v	13	70	43	95	27	94
RU PowerMax + N-Pak AMS + Prefer 90 NIS	22 fl oz/a + 8.5 lb /100gal + 0.25 % v/v	23	83	45	96	30	91
RU PowerMax + Nano-Revolution 2.0	22 fl oz/a + 2 fl oz/a	23	83	39	98	30	96
RU PowerMax + Nano-Revolution 2.0	22 fl oz/a + 4 fl oz/a	13	87	35	91	33	96
LSD (0.05)		NS	NS	NS	NS	NS	NS
CV		55	14	16	7	30	5

SUGARBEET INJURY AND WEED CONTROL FROM RO-NEET SB AND OTHER SOIL APPLIED HERBICIDES IN ROUNDUP READY® SUGARBEET AT HICKSON, NORTH DAKOTA IN 2015

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The objective of this study was to evaluate Ro-Neet SB applied alone and in combination with other soil-applied herbicides for weed control and injury to Roundup Ready (RR) sugarbeet.

MATERIALS AND METHODS

'SV 36272 RR' sugarbeet was seeded 1 inch deep in 22 inch rows at 60,560 seeds per acre on May 9. Sugarbeet was treated with Tachigaren, Kabina, and NipsIt Suite at 45 grams product, 7 grams ai, and 3.4619 fl oz product, respectively, per 100,000 seeds. Herbicide treatments were applied May 9 with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO2 at 40 psi to the center four rows of six row plots 25 feet in length. Preplant incorporated (PPI) treatments were incorporated immediately following application using a rototiller set 3 to 4 inches deep. Preemergence treatments were applied following planting. Sugarbeet injury and weed control were evaluated June 4 and June 10. All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Table 1. Application Information

Application Code	PPI	PRE
Date	9 May	9 May
Time of Day	10:15 AM	4:10 PM
Air Temperature (F)	40	53
Relative Humidity (%)	69	38
Wind Velocity (mph)	8	14
Wind Direction	N	N
Soil Temp. (F at 6")	42	42
Soil Moisture	Fair	Fair
Cloud Cover	95	80
Sugarbeet stage (avg)	PPI	PRE

SUMMARY

Sugarbeet stands were somewhat variable in this study, even in the untreated check. Sugarbeet injury from Eptam + Ro-Neet, Eptam, Nortron, or Dual Magnum tended to be greater than from Ro-Neet alone or the untreated check (Table 2). However, due to the variability in sugarbeet stand and the lack of yield data from this study, sugarbeet injury data should be combined with data from other studies in making recommendations.

Heavy infestations of redroot pigweed and common lambsquarters were present throughout this study. Oat and foxtail millet were seeded in strips, perpendicular to sugarbeet and provided good means for evaluating grass control.

Ro-Neet applied PRE did not provide adequate control of any species evaluated. Ro-Neet plus Dual Magnum applied PRE improved lambsquarters and oat control compared to either product alone. Ro-Neet plus HAI-2015 PRE provided similar control to Ro-Neet PRE.

Preplant incorporated application of Ro-Neet plus Nortron (ethofumesate) at a reduced rate did not provide commercially acceptable grass or broadleaf weed control. Reduced application rates of Nortron in other studies at other locations this year gave similar results. Ro-Neet plus Eptam applied PPI gave broad spectrum grass and small seeded broadleaf weed control.

Table 2. Sugarbeet injury and weed control from Ro-Neet SB and other soil applied herbicides at Hickson, ND in 2015.

			4 Jun				10 Jun				
			Sgbt Inju	Rrpw Cntl	Oat Cntl	Colq Cntl	Sgbt Inju	Rrpw Cntl	Oat Cntl	Colq Cntl	Fxmi Cntl
Treatment	Rate	Appl	%								
Untreated Check			5	0	5	0	0	0	8	0	0
Ro-Neet SB	4.5 pt/a	PPI	10	66	45	54	9	49	35	54	99
Ro-Neet SB	5.36 pt/a	PPI	10	70	73	66	0	56	65	49	100
Ro-Neet SB + Eptam	2.67 + 2.29 pt/a	PPI	8	85	100	91	20	78	100	91	100
Ro-Neet SB + Eptam	4.5 + 2.29 pt/a	PPI	18	86	97	84	20	86	100	93	100
Ro-Neet SB + Nortron	2.67 + 2 pt/a	PPI	13	69	45	50	5	74	18	56	98
Ro-Neet SB + Nortron	2.67 + 3 pt/a	PPI	9	68	58	58	9	50	35	53	78
Eptam	3.5 pt/a	PPI	13	77	99	90	25	73	99	90	100
Nortron	7.5 pt/a	PPI	10	91	73	82	23	86	55	83	91
Ro-Neet SB	4.5 pt/a	PRE	10	51	38	45	0	43	33	33	55
Ro-Neet SB + HAI-2015	4.5 + 1 pt/a	PRE	10	44	53	34	9	48	40	38	73
Ro-Neet SB + HAI-2015 + Dual Magnum	2.67 + 0.69 + 0.5 pt/a	PRE	13	91	40	71	11	88	25	61	90
Ro-Neet SB + HAI-2015 + Dual Magnum	2.67 + 0.69 + 0.75 pt/a	PRE	15	96	45	80	14	97	43	79	98
Dual Magnum	0.75 pt/a	PRE	18	97	3	65	15	94	5	54	93
LSD 5%			NS	22	17	21	14	23	22	23	18
CV %			86	22	22	24	84	24	33	28	15