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

<u>Impact of soil-applied herbicides on spring-seeded cereal cover crops</u>

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

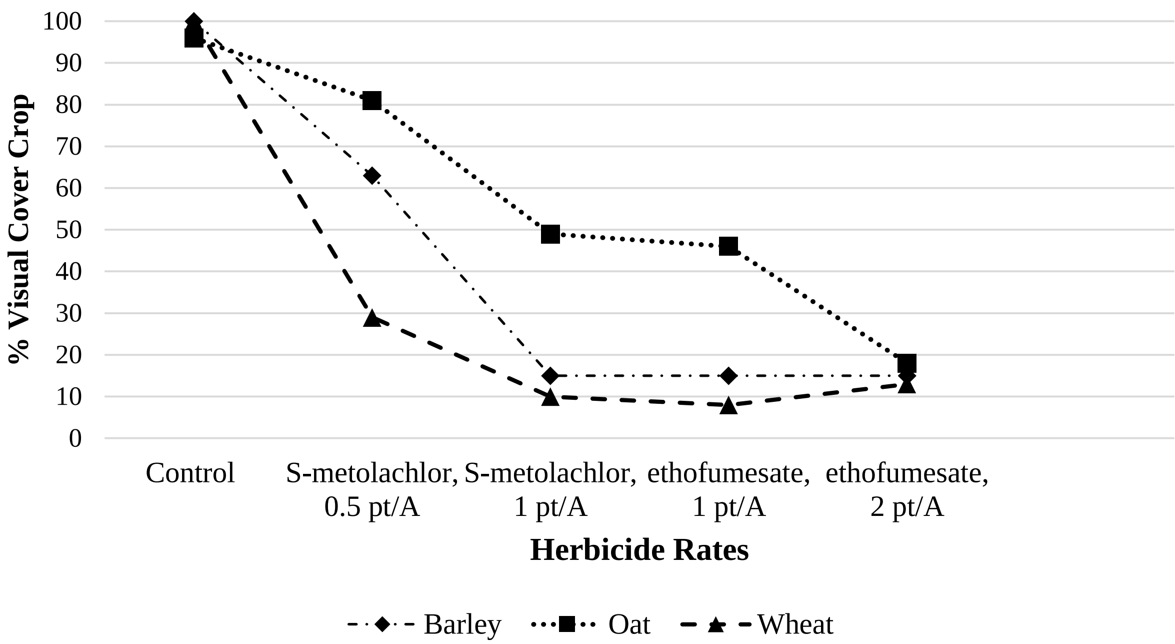

Figure 1. Impact of soil-applied herbicides and herbicide rate on Barley, oat and wheat visual ground cover, 35 days after planting, Foxhome, MN, 2015

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

Literature Cited

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