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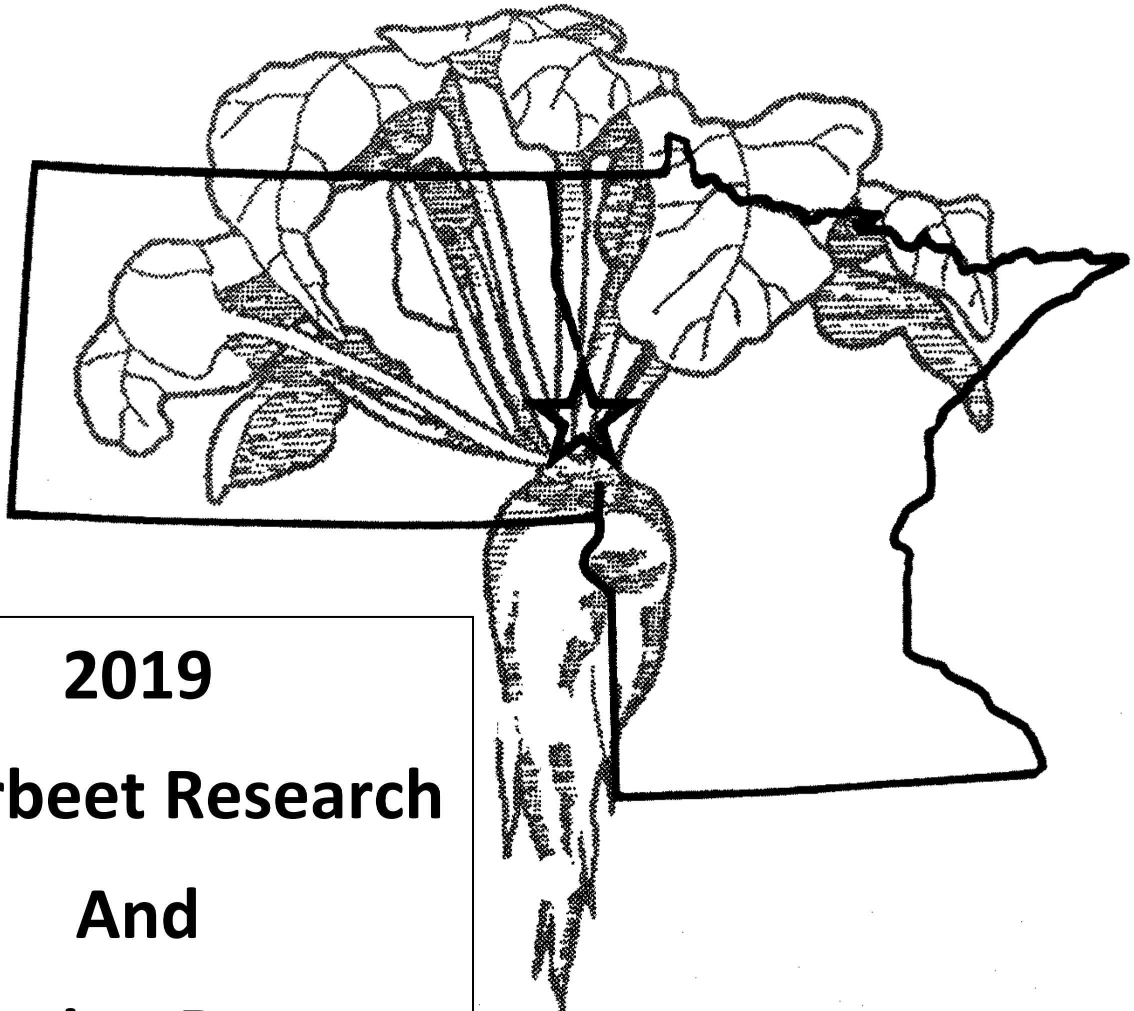

2019 Sugarbeet Research And Extension Reports

* The reports marked with an asterisk were supported partially by sugarbeet grower check off funds administered by the sugarbeet Research and Education Board of Minnesota and North Dakota. Funds were contributed by American Crystal Sugar Company, Minn-Dak Farmers Cooperative, and Southern Minnesota Beet Sugar Cooperative.

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WEED CONTROL

NOTES

TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2018

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The fourth annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2019 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2018 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND, and Willmar, MN, Growers Seminars. Respondents from each seminar indicated the county in which the majority of their sugarbeet were produced (Tables 1, 2, 3, 4, 5). Survey results represents approximately 193,050 acres reported by 277 respondents (Table 6) compared to 198,500 acres represented in 2017. The average sugarbeet acreage per respondent grown in 2018 was calculated from Table 6 at 697 acres compared to 634 acres in 2017.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2018. Fifty-four percent of respondents indicated wheat was the crop preceding sugarbeet (Table 7), 23% indicated corn, and 13% indicated soybean. Preceding crop varied by location with 84% of Grand Forks growers indicating wheat preceded sugarbeet and 73% of Willmar growers indicated corn as their preceding crop. Seventy-seven percent of growers who participated in the winter meetings used a nurse or cover crop in 2018 (Table 8) which increased from 74% in 2017. Cover crop species also varied widely by location with barley being used by 63% of growers at the Fargo meeting and oat being used by 46% of growers at the Willmar meeting.

Growers indicated Cercospora Leaf Spot (CLS) was their most serious production problem in sugarbeet in 2018 (Table 9) with 42% of all respondents naming CLS compared to Rhizoctonia being named most serious problem by 27% of participants in 2017. In 2018, Rhizoctonia was the most serious problem for 22% of respondents and weeds were named as most serious by 14% of respondents.

Waterhemp was named as the most serious weed problem in sugarbeet in 2018 by 54% of respondents (Table 10) compared to 48% in 2017. Six percent of respondents indicated common lambsquarters, 9% kochia, and 18% said common ragweed were their most serious weed problem in 2018. The increased presence of glyphosate-resistant waterhemp and common ragweed are likely the reason for these weeds being named as the worst weeds. Troublesome weeds varied by location with greater than 91%, 90%, and 81% of Willmar, Wahpeton, and Fargo respondents, respectively, indicating waterhemp was most problematic weed. Common ragweed was the worst weed for respondents of the Grand Forks meeting with 46% of responses.

Respondents to the survey indicated making 0 to 5 glyphosate applications in their 2018 sugarbeet crop (Table 11) with a calculated average of 2.16 applications per acre. The calculated average in 2017 was 2.21 applications per acre.

Glyphosate was most commonly applied with a broadleaf herbicide postemergence in 2018 with 34% of responses indicating this herbicide combination was used (Table 12). Glyphosate applied with a chloroacetamide herbicide postemergence (lay-by) was the second most common herbicide used in sugarbeet in 2018 with 30% of responses. Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 24% and 8% of the responses.

Satisfaction to weed control from glyphosate applied alone is shown in Table 13 and ranged from 17% of responses indicating excellent control to 6% of responses indicating poor weed control. The majority of responses, 40%, indicated glyphosate was still providing good weed control in sugarbeet in 2018.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 46% of survey respondents in 2018 (Table 14). Less than 10% of Grand Forks survey participants applied a PPI or PRE herbicide. Conversely, 89% of

Wahpeton survey participants did apply a PPI or PRE herbicide in sugarbeet in 2018 compared to 83% in 2017. Once again, a likely reason for this variation is the more common presence of glyphosate-resistant waterhemp in the southern sugarbeet growing areas of the Red River Valley compared to the north end of the Valley. The most commonly used soil herbicide was S-metolachlor with 25% of all responses followed by ethofumesate with 9% of responses (Table 14). Of the growers who indicated using a soil-applied herbicide, 67% indicated excellent to good weed control from that herbicide (calculated from Table 15).

The application of soil-residual herbicides applied ‘lay-by’ to the 2018 sugarbeet crop was indicated by 63% of respondents (Table 16). Outlook was the most commonly applied lay-by herbicide with 31% of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (69% of responses), while S-metolachlor was more commonly applied by growers of the Wahpeton (68% of responses) and Fargo (64% of responses) meetings. Ninety-five percent, 95%, and 82% of Willmar, Wahpeton, and Fargo respondents, respectfully, applied glyphosate with Outlook, S-metolachlor, or Warrant but only 21% and 6% of Grand Forks and Grafton respondents, respectfully, used this combination (Table 16). Use of chloroacetamide herbicides with glyphosate seems to coincide greatest to areas where glyhphosate-resistant waterhemp is common.

Satisfaction of weed control from lay-by applications ranged from excellent to unsure (Table 17). Of respondents indicating they applied a lay-by herbicide, 73% indicated excellent or good weed control (calculated from Table 17).

Fifty-eight percent of survey respondents indicated using some form of mechanical weed control or hand labor in 2018 (Table 18). Of the responses given, 39% indicated at least some hand-weeding, 15% used row-cultivation, and 1% indicated using a rotary hoe for weed control in sugarbeet. Fifteen percent reported row-crop cultivation on less than ten percent of their acres (Table 19).

Hand-weeding the 2018 sugarbeet crop was reported by 54% of respondents (Table 20). Most respondents who hand-weeded indicated less than 10% of their acres were hand-weeded. Fewer than half of the respondents indicated hand-weeding at the Grafton, Wahpeton, and Grand Forks meetings, while greater than half the participants at the Fargo and Willmar meeting reported some hand weeding.

Table 1. 2019 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Becker	1	3
Cass	12	32
Clay	10	26
Norman[1]	12	32
Richland	2	4
Traill	1	3
Total	38	100

[1]Includes Mahnomen County

Table 2. 2019 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Grand Forks	3	8
Kittson	5	13
Marshall	2	5
Pembina	13	33
Walsh	14	36
Other	2	5
Total	39	100

Table 3. 2019 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County		Number of Responses	Percent of Responses
Grand Forks		19	21
Mahnomen		1	1
Marshall		9	10
Pennington[1]		1	1
Polk		45	51
Traill		2	2
Walsh		4	5
Other		8	9
	Total	89	100

[1]Includes Red Lake

Table 4. 2019 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in 2018.

County		Number of Responses	Percent of Responses
Clay		3	10
Grant		4	13
Richland		6	20
Traverse		1	3
Wilkin		16	54
	Total	30	100

Table 5. 2019 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2018.

County		Number of Responses	Percent of Responses
Chippewa		27	33
Kandiyohi		8	10
Pope		1	1
Redwood		4	5
Renville		26	32
Stevens		5	6
Swift		6	8
Other		4	5
	Total	81	100

Table 6. Total sugarbeet acreage operated by respondents in 2018.

		Acres of sugarbeet									
Location	Responses	<99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		---------------------% of responses---------------------									
Fargo	36	6	6	8	2	28	17	6	8	11	8
Grafton	42	5	14	0	10	33	14	17	5	2	0
Grand Forks	83	11	7	5	4	16	20	7	17	8	5
Wahpeton	30	7	3	0	30	20	10	7	13	7	3
Willmar	82	7	12	10	6	17	18	4	15	10	1
Total	273	8	9	5	8	21	17	7	13	8	4

Table 7. Crop grown in 2017 that preceded sugarbeet in 2018.

		Previous Crop								
Location	Responses	Barley	Canola	Sweet Corn	Field Corn	Dry Bean	Potato	Soybean	Wheat	Other
		--------------------------------% of responses--------------------------------------								
Fargo	37	11	0	0	0	0	0	22	67	0
Grafton	44	0	0	0	0	7	9	7	77	0
Grand Forks	86	3	0	0	1	3	6	3	84	0
Wahpeton	30	0	0	0	13	3	0	17	67	0
Willmar	82	0	0	5	73	1	0	20	0	1
Total	279	2	0	1	23	3	3	13	54	<1

Table 8. Nurse or cover crop used in sugarbeet in 2018.

Location	Responses	Barley	Oat	Rye	Wheat	Other[1]	None
		---------------------------------% of responses----------------------------					
Fargo	38	63	3	0	8	0	26
Grafton	45	24	11	0	29	0	36
Grand Forks	93	44	0	1	25	0	30
Wahpeton	28	54	0	0	36	0	10
Willmar	83	2	46	3	37	0	12
Total	287	32	15	2	28	0	23

[1]Includes Mustard and 'Other'

Table 9. Most serious production problem in sugarbeet in 2018.

Location	Responses	CLS[1]	Rhizo-mania	Aph[2]	Rhizoc-tonia	Fusarium	Herbicide Injury	Root Maggot	Weeds	Stand[3]
		-----------------------------% of responses--								
Fargo	38	26	0	5	32	0	3	0	26	8
Grafton	43	16	0	14	26	0	5	18	16	5
Grand Forks	84	32	2	8	24	1	1	4	16	12
Wahpeton	31	55	0	0	16	3	0	0	10	16
Willmar	82	68	1	3	16	0	0	0	7	5
Total	278	42	1	6	22	<1	1	4	14	9

[1]Cercospora Leaf Spot
[2]Aphanomyces
[3]Emergence/Stand

Table 10. Most serious weed problem in sugarbeet in 2018.

Location	Responses	biww[1]	colq	cora	kochia	gira	rrpw	RR Canola	wahe
		----------------------------------% of responses--------------------------							
Fargo	38	3	0	8	5	3	0	0	81
Grafton	46	2	13	11	21	2	20	11	20
Grand Forks	87	0	10	46	15	9	5	1	14
Wahpeton	29	0	0	7	3	0	0	0	90
Willmar	80	0	4	0	0	4	0	1	91
Total	280	<1	6	18	9	5	5	2	54

[1]biww=biennial wormwood, colq=common lambsquarters, cora=common ragweed, gira=giant ragweed, rrpw=redroot pigweed, wahe=waterhemp

Table 11. Average number of glyphosate applications per acre in sugarbeet during 2018 season.

Location	Responses	0	1	2	3	4	5
		-------------------------	% of responses	----------------------------			
Fargo	38	0	16	63	21	0	0
Grafton	43	0	7	65	28	0	0
Grand Forks	86	1	13	57	27	1	1
Wahpeton	30	0	10	57	33	0	0
Willmar	80	0	19	54	24	1	2
Total	277	<1	14	57	26	<1	1

Table 12. Herbicides used in a weed control systems approach in sugarbeet in 2018.

		Glyphosate Application Tank-Mixes					
Location	Responses	Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		--------------------------------------	% of responses	-----------------------------------			
Fargo	37	19	35	38	5	3	0
Grafton	39	67	0	28	0	3	3
Grand Forks	83	33	2	57	1	5	2
Wahpeton	30	7	50	33	10	0	0
Willmar	79	3	65	10	19	3	1
Total	268	24	30	34	8	3	1

Table 13. Satisfaction in weed control from glyphosate applied in sugarbeet in 2018.

		Satisfaction of Weed Control from Glyphosate					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	Not Used Alone
		---------------------------------	% of responses	----------------------------			
Fargo	39	5	26	46	13	0	10
Grafton	41	37	56	7	0	0	0
Grand Forks	79	20	43	16	4	3	14
Wahpeton	30	0	30	23	10	0	37
Total	189	17	40	22	6	1	14

Table 14. Preplant incorporated or preemergence herbicides used in sugarbeet in 2018.

		PPI or PRE Herbicides Applied					
Location	Responses	S-metolachlor	ethofumesate	Ro-Neet SB	S-metolachor +ethofumesate	Other	None
		--------------------------------------	% of responses	----------------------------------			
Fargo	40	50	8	0	2	5	35
Grafton	39	0	0	3	7	3	87
Grand Forks	82	6	0	0	0	1	93
Wahpeton	28	50	11	0	28	0	11
Willmar	82	36	22	1	6	12	23
Total	271	25	9	<1	6	5	54

Table 15. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2018.

		PPI or PRE Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		------------------------------	% of responses	--------------------------			
Fargo	37	16	30	27	0	0	27
Grafton	40	2	5	8	0	2	83
Grand Forks	84	3	10	0	0	2	85
Wahpeton	31	3	70	10	7	3	7
Willmar	81	7	43	24	6	0	20
Total	273	6	29	13	3	1	48

Table 16. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2018.

Location	Responses	Lay-by Herbicides Applied				
		S-metolachlor	Outlook	Warrant	Other	None
		---% of responses---				
Fargo	62	64	13	3	2	18
Grafton	52	4	2	0	0	94
Grand Forks	94	7	12	1	1	79
Wahpeton	41	68	27	0	0	5
Willmar	123	6	69	20	0	5
Total	372	23	31	8	<1	38

Table 17. Satisfaction of weed control from soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2018.

Location	Responses	Lay-by Weed Control Satisfaction					
		Excellent	Good	Fair	Poor	Unsure	None Used
		---% of responses---					
Fargo	36	8	53	14	3	0	22
Grafton	39	5	0	5	0	0	90
Grand Forks	79	9	6	1	0	3	81
Wahpeton	30	3	77	10	7	0	3
Willmar	79	5	61	29	3	1	1
Total	263	7	36	13	2	1	41

Table 18. Mechanical weed control methods used in sugarbeet in 2018.

Location	Responses	Rotary Hoe	Row-Cultivation	Hand-Weeded	Other	None
		---% of responses---				
Fargo	44	0	18	46	0	36
Grafton	44	2	9	25	2	62
Grand Forks	92	1	3	29	6	61
Wahpeton	30	0	3	47	3	47
Willmar	102	1	29	49	2	19
Total	312	1	15	39	3	42

Table 19. Percent of sugarbeet acres row-crop cultivated in 2018.

Location	Responses	% Acres Row-Cultivated				
		0	< 10	10-50	51-100	>100
		---% of responses---				
Fargo	39	77	13	10	0	0
Grafton	41	85	12	3	0	0
Grand Forks	84	80	18	0	0	2
Wahpeton	30	74	20	3	0	3
Willmar	81	51	12	9	13	15
Total	275	71	15	5	4	5

Table 20. Percent of sugarbeet acres hand-weeded in 2018.

Location	Responses	% Acres Hand-Weeded				
		0	< 10	10-50	51-100	>100
		---% of responses---				
Fargo	39	33	54	13	0	0
Grafton	42	62	31	7	0	0
Grand Forks	85	56	36	4	4	0
Wahpeton	30	60	20	17	3	0
Willmar	82	28	23	32	4	13
Total	278	46	32	15	3	4

INTEGRATING HERBICIDES AND INTER-ROW CULTIVATION

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INTRODUCTION

The spread of glyphosate resistant waterhemp in Minnesota and North Dakota has sugarbeet growers looking into weed control methods that will supplement chemical control.

MATERIALS AND METHODS

An experiment was conducted on common lambsquarters and waterhemp near Moorhead, MN in 2019. The trial site was prepared for planting using a Kongskilde s-tine field cultivator on May 9, 2019. 'CR 355' sugarbeet was planted in 22-inch rows at 61,500 seeds per acre on May 10 with a six-row planter. Preemergence (PRE) treatments were applied May 10. Postemergence (POST) treatments were applied June 6 and 19. All herbicide treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 30 feet in length. A maintenance application of Roundup PowerMax at 22 fl oz/A was applied to the entire trial site on June 13 to reduce competition from common lambsquarters and allow waterhemp emergence. Cultivation treatment was applied June 25 to the center 4 rows of appropriate plots. The cultivator was operated at 4 mph, set 1 to 1.5 inches deep, and equipped with sweeps that tilled 15 inches of soil surface between rows. Sugarbeet injury and common lambsquarters control were evaluated June 6, 26, July 15, and August 9, 2019. Waterhemp control was evaluated June 26, July 15, and August 9. Sugarbeet were harvested September 20 by defoliating the center 4 rows of 30' long plots and harvesting the center 2 rows with a two-row sugarbeet harvester. Sugarbeets were weighed and a subsample of about 25 lbs. of normal, representative roots from each plot were collected and taken to the American Crystal Tare Lab in East Grand Forks, MN for quality analysis.

Table 1. Application Information – Moorhead, MN 2019

Application	A	B	C	Cultivation
Date	May 10	June 6	June 19	June 25
Time of Day	6:00 PM	9:00 AM	12:30 PM	
Air Temperature (F)	64	77	76	
Relative Humidity (%)	26	42	44	
Wind Velocity (mph)	10	2	2	
Wind Direction	SW	NW	SE	
Soil Temp. (F at 6")	50	68	66	
Soil Moisture	Good	Good	Good	Sli Wet
Cloud Cover (%)	80	0	0	
Sugarbeet Stage	PRE	2-lf	8-lf	12-lf
Common Lambsquarters	PRE	1 in	3 in	
Waterhemp	PRE	0 in	3 in	

All sugarbeet injury and weed control evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. The experiment was a 2x4 factorial split-block arrangement in a randomized complete block design with 4 replications. Each replication (block) was "grid split" where the factor A was cultivation at two levels and the factor B was herbicide at four levels. Data were analyzed with the ANOVA procedure of ARM, version 2019.4, software package.

RESULTS

Cultivation (factor A) had no impact on sugarbeet injury at either evaluation (Table 2). Herbicide (factor B) had no impact on sugarbeet injury at either evaluation.

Table 2. Sugarbeet Injury at Moorhead, MN, 2019.

Treatment	Rate	Timing[3]	Percent Sugarbeet Injury	
	(fl oz/A)		June 6	June 26
FACTOR A - Cultivation				
NO Cultivation	-	-	9	8
Cultivation	-	Cultivation	8	7
FACTOR A LSD (0.05)			**NS**	**NS**
FACTOR B - Herbicide				
Dual Magnum	8	A	7	3
Dual Magnum fb	8 fb	A fb		
POST[1] + Outlook fb	1x[2] + 18 fb	B fb	8	8
POST	1x	C		
Dual Magnum fb	8 fb	A fb		
POST fb	1x fb	B fb	13	9
POST + Outlook	1x + 18	C		
Dual Magnum fb	8 fb	A fb		
POST + Outlook fb	1x + 12 fb	B fb	7	11
POST + Outlook	1x + 12	C		
FACTOR B LSD (0.05)			**NS**	**NS**

[1] POST = Roundup PowerMax @ 28 fl oz/A + Ethofumesate 4SC @ 6 fl oz/A + Destiny HC @ 1.5 pt/A + NPak AMS at 2.5% v/v

[2] 1x = rates specified in footnote 1.

[3] Timing refers to application timings in Table 1.

Cultivation (factor A) had no significant impact on common lambsquarters control at any evaluation timing (Table 3). Herbicide (factor B) significantly impacted common lambsquarters control at all evaluations taken after all herbicide application timings were completed. Dual Magnum at 0.5 pt/A was applied PRE on all plots and gave 68% to 78% control of common lambsquarters. Plots receiving two applications of POST herbicides following PRE Dual Magnum showed 97% to 99% lambsquarters control later in the season compared to 38% to 70% control in plots receiving only PRE Dual Magnum. Cultivation did not impact common lambsquarters control when POST herbicides were applied (data not shown), but PRE Dual Magnum followed by cultivation tended to give 15% to 20% greater common lambsquarters control compared to PRE Dual Magnum without cultivation (data not shown).

Table 3. Common Lambsquarters Control at Moorhead, MN, 2019.

Treatment	Rate	Timing[3]	Percent Common Lambsquarters Control			
	(fl oz/A)		June 6	June 26	July 15	August 8
FACTOR A - Cultivation						
NO Cultivation	-	-	72	85	88	86
Cultivation	-	Cultivation	70	81	94	90
FACTOR A LSD (0.05)			**NS**	**NS**	**NS**	**NS**
FACTOR B - Herbicide						
Dual Magnum	8	A	68	38	70	55
Dual Magnum fb	8 fb	A fb				
POST[1] + Outlook fb	1x[2] + 18 fb	B fb	78	99	98	99
POST	1x	C				
Dual Magnum fb	8 fb	A fb				
POST fb	1x fb	B fb	69	97	97	99
POST + Outlook	1x + 18	C				
Dual Magnum fb	8 fb	A fb				
POST + Outlook fb	1x + 12 fb	B fb	70	99	99	99
POST + Outlook	1x + 12	C				
FACTOR B LSD (0.05)			**NS**	**11**	**11**	**8**

[1] POST = Roundup PowerMax @ 28 fl oz/A + Ethofumesate 4SC @ 6 fl oz/A + Destiny HC @ 1.5 pt/A + NPak AMS at 2.5% v/v

[2] 1x = rates specified in footnote 1.

[3] Timing refers to application timings in Table 1.

Cultivation (factor A) had no significant impact on waterhemp control at June and July evaluation timings (Table 4). The August evaluation showed cultivation gave an improvement in waterhemp control compared to no cultivation, though the difference was slight. Herbicide (factor B) significantly impacted waterhemp control at all evaluations. Dual Magnum at 0.5 pt/A was applied PRE and gave 41% to 74% control of wtaerhemp. Plots receiving two applications of POST herbicides following PRE Dual Magnum showed 96% to 99% waterhemp control. Cultivation did not impact waterhemp control when POST herbicides were applied (data not shown), but PRE Dual Magnum followed by cultivation tended to give 10% to 15% greater waterhemp control compared to PRE Dual Magnum without cultivation (data not shown).

Table 4. Waterhemp Control at Moorhead, MN, 2019.

Treatment	Rate	Timing[3]	Percent Waterhemp Control		
	(fl oz/A)		June 26	July 15	August 8
FACTOR A - Cultivation					
NO Cultivation	-	-	85	89	87
Cultivation	-	Cultivation	82	95	91
FACTOR A LSD (0.05)			**NS**	**NS**	**3.3**
FACTOR B - Herbicide					
Dual Magnum	8	A	41	74	62
Dual Magnum fb	8 fb	A fb			
POST[1] + Outlook fb	1x[2] + 18 fb	B fb	96	99	98
POST	1x	C			
Dual Magnum fb	8 fb	A fb			
POST fb	1x fb	B fb	98	97	99
POST + Outlook	1x + 18	C			
Dual Magnum fb	8 fb	A fb			
POST + Outlook fb	1x + 12 fb	B fb	99	99	99
POST + Outlook	1x + 12	C			
FACTOR B LSD (0.05)			**16**	**10**	**7**

[1] POST = Roundup PowerMax @ 28 fl oz/A + Ethofumesate 4SC @ 6 fl oz/A + Destiny HC @ 1.5 pt/A + NPak AMS at 2.5% v/v
[2] 1x = rates specified in footnote 1.
[3] Timing refers to application timings in Table 1.

Impacts of cultivation and herbicide on yield followed a very similar trend as has been discussed with respect to weed control. Cultivation (factor A) had no significant impact on yield parameters (Table 5). There is a slight numeric trend towards greater root yield (1.3 ton/A) and greater extractable sucrose (353 lb/A) from cultivation, but the impact was not statistically significant. Herbicide (factor B) significantly impacted root yield, but did not impact sugar percentage or extractable sucrose per acre. Dual Magnum at 0.5 pt/A applied PRE gave 27.0 ton/A root yield, while plots receiving two applications of POST herbicides following PRE Dual Magnum gave 29.9 to 31.3 tons/A. Cultivation did not impact root yield or extractable sucrose when POST herbicides were applied (data not shown), but PRE Dual Magnum followed by cultivation gave 6.2 tons/A greater root yield and 1,200 lbs/A greater extractable sucrose compared to PRE Dual Magnum without cultivation (data not shown).

CONCLUSIONS

Common lambsquarters was very dense in this trial in late May and early June and was actually suppressing waterhemp germination. Waterhemp started to emerge following an across trial application of Roundup PowerMax at 22 fl oz/A on June 13. The main influence on weed control as the season progressed was not cultivation, but rather Outlook herbicide. For both common lambsquarters and waterhemp, the greatest control was observed when Outlook was applied early POST (2 leaf), late POST (8 leaf), or as a split application at both timings. Due to the early season interference from common lambsquarters, waterhemp emergence was delayed and both POST timings of Outlook were effective at controlling waterhemp. The broadcast application of Roundup PowerMax at 22 fl oz/A allowed us to observe the PRE followed by a single POST application system. This system was not effective at controlling either waterhemp or common lambsquarters under very dense weed pressure. Higher rates of Roundup may have improved common lambsquarters control, but increased rates of POST applied glyphosate would not have improved control of the glyphosate-resistant waterhemp.

Table 5. Yield Impacts from cultivation and herbicide at Moorhead, MN, 2019.

Treatment	Rate	Timing[3]	Yield	Sugar	Ext. Sucrose
	(fl oz/A)		Ton/A	%	Lb/A
FACTOR A - Cultivation					
NO Cultivation	-	-	29.1	13.7	7,154
Cultivation	-	Cultivation	30.4	13.7	7,507
FACTOR A LSD (0.05)			**NS**	**NS**	**NS**
FACTOR B - Herbicide					
Dual Magnum	8	A	27.0	13.7	6,679
Dual Magnum fb	8 fb	A fb			
POST[1] + Outlook fb	1x[2] + 18 fb	B fb	30.7	13.6	7,485
POST	1x	C			
Dual Magnum fb	8 fb	A fb			
POST fb	1x fb	B fb	29.9	13.9	7,485
POST + Outlook	1x + 18	C			
Dual Magnum fb	8 fb	A fb			
POST + Outlook fb	1x + 12 fb	B fb	31.3	13.7	7,673
POST + Outlook	1x + 12	C			
FACTOR B LSD (0.05)			**3.5**	**NS**	**NS**

[1] POST = Roundup PowerMax @ 28 fl oz/A + Ethofumesate 4SC @ 6 fl oz/A + Destiny HC @ 1.5 pt/A + NPak AMS at 2.5% v/v

[2] 1x = rates specified in footnote 1.

[3] Timing refers to application timings in Table 1.

The impact of cultivation on weed control was skewed in this trial. In the plots that received only Dual Magnum PRE, weed pressure was quite heavy. It was in these weedy plots that we observed the greatest impact from cultivation on weed control. This observation is logical and supports what we've known for many years: cultivation in weedy fields generally helps eliminate some weeds and typically improves overall weed control. The weed pressure was lighter in the plots that received POST herbicides and there was less benefit from cultivation. However, no negative effects from cultivation such as increased root disease was observed. Likewise, cultivation did not negatively affect Outlook, which to be effective, must be evenly distributed in the top inch of the soil horizon for weeds to absorb the herbicide and to be controlled.

RO-NEET AND EPTAM WEED EFFICACY AND SUGARBEET TOLERANCE

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INTRODUCTION

Sugarbeet yield loss to weed interference averaged 70% in sugarbeet growing areas in North America (Soltani et al. 2018). This equates to about $211 and $369 million loss of income from sugarbeet production in North Dakota and Minnesota, respectively. Cycloate, pyrazon, ethofumesate, and EPTC were applied preplant incorporated (PPI) or preemergence (PRE) for weed control in sugarbeet fields in the Red River Valley and Michigan from 1970 to the mid-1980s (Dale et al. 2006). However, use of soil-applied herbicides declined to less than 5% of sugarbeet acres in North Dakota and Minnesota in the mid-1980s because of reliance on POST herbicides and cultivation (Luecke and Dexter 2003). Weeds continue to be a major concern due to limited herbicide options within sugarbeet. EPTC and cycloate could reemerge as important herbicides for weed control.

The objective of this experiment was to evaluate weed control and sugarbeet tolerance from Ro-Neet and Eptam alone or in mixtures.

MATERIALS AND METHODS

Experiments were conducted on natural weed populations and bioassay species strips near Hickson, ND in 2015, 2016, 2018, and 2019. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at 60,560 seeds per acre with 4.7 inch spacing between seeds.

Herbicide treatments included PPI applications of Ro-Neet, Eptam, and Ro-Neet + Eptam at multiple rates in 2015, 2016, 2018 (Table 1) and 2019 (Table 2). 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 35 feet in length. Herbicides were immediately incorporated using a rototiller set 3 to 4 inches deep. The center 8 feet of each plot was rototilled to remove the variability that could otherwise be caused by the incorporating tillage.

Table 1. Herbicide treatments, rates, and application timing in trials near Hickson, ND in 2015, 2016, and 2018.

Herbicide Treatment	Rate (pt/A)	Timing of Application
Ro-Neet SB	4.5	PPI
Ro-Neet SB	5.36	PPI
Ro-Neet SB + Eptam	2.67 + 2.29	PPI
Ro-Neet SB + Eptam	4.5 + 2.29	PPI
Eptam	3.5	PPI

Table 2. Herbicide treatments, rates, and application timing in trials near Hickson, ND in 2019.

Herbicide Treatment	Rate (pt/A)	Timing of Application
Ro-Neet SB	4.5	PPI
Ro-Neet SB	5.36	PPI
Ro-Neet SB + Eptam	2.67 + 2.29	PPI
Ro-Neet SB + Eptam	4.5 + 2.29	PPI
Eptam	3.5	PPI
Eptam	2.5	PPI

Sugarbeet tolerance and grass and broadleaf weed control were evaluated visually, beginning approximately seven days after sugarbeet emergence. Sugarbeet emergence date was dependent on growing conditions in each year. Evaluations generally were on weekly intervals following the first evaluation and continued until weeds overtook the plots. Sugarbeet injury and common lambsquarters, redroot pigweed, foxtail millet, and oat control was evaluated in 2019. All evaluations were a visual estimate of control 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 2019.4 software package.

RESULTS

EPTAM AND RO-NEET ACROSS YEARS

Sugarbeet injury was greater or tended to be greater from Eptam or Ro-Neet SB plus Eptam compared to Ro-Neet SB alone at 4.5 or 5.36 pt/A. (Table 3). Sugarbeet injury from Ro-Neet SB + Eptam at 2.67 + 2.29 pt/A was the same as sugarbeet injury from Ro-Neet SB + Eptam at 4.5 + 2.29 pt/A. Injury tended to decrease from 7 days after emergence (DAE) to 28 DAE.

Table 3. Sugarbeet injury 7, 14, and 28 days after emergence (DAE) combined across years.

		Sugarbeet Growth Reduction		
Treatment	Rate	7 DAE	14 DAE	28 DAE
	--pt/A--	-------------------%---------------------		
Ro-Neet SB	4.5	18	5 a	3 a
Ro-Neet SB	5.36	20	6 a	10 ab
Ro-Neet SB + Eptam	2.67 + 2.29	44	32 b	26 bc
Ro-Neet SB +Eptam	4.5 + 2.29	50	33 b	31 c
Eptam	3.5	48	43 b	30 c
LSD (0.05)		NS	13	16

Redroot pigweed control from Eptam alone or Ro-Neet SB + Eptam was greater than pigweed control from Ro-Neet SB alone (Table 4). There was no statistical difference in control between Eptam at 3.5 pt/A and Ro-Neet SB + Eptam at 2.67 + 2.29 pt/A or Ro-Neet SB + Eptam at 4.5 + 2.29 pt/A. However, numeric control tended to be greatest from Ro-Neet SB + Eptam at 4.5 + 2.29 pt/A. Redroot pigweed control from Ro-Neet SB at 5.36 pt/A was greater than pigweed control from Ro-Neet at 4.5 pt/A. However, control was less than Eptam or Ro-Neet SB plus Eptam treatments. Treatments that gave the greatest pigweed control 7 DAE also gave the greatest control 14 and 28 DAE. However, control tended to decline as time progressed. Oat control from Eptam or Ro-Neet SB plus Eptam was greater than 95% across all evaluation timings. Oat control from Ro-Neet SB at 4.5 or 5.36 pt/A was less than control from Ro-Neet SB + Eptam at either 2.67 or 4.5 pt/A + 2.29 pt/A.

Table 4. Redroot pigweed and wild oat control 7, 14, and 28 days after emergence (DAE) combined across years.

		Redroot Pigweed Control			Wild Oat Control		
Treatment	Rate	7 DAE	14 DAE	28 DAE	7 DAE	14 DAE	28 DAE
	--pt/A--	---------------------------------%--------------------------------					
Ro-Neet SB	4.5	74 c	61 c	34 b	66 c	60 b	49 c
Ro-Neet SB	5.36	81 b	72 b	41 b	82 b	74 b	66 b
Ro-Neet SB + Eptam	2.67 + 2.29	94 a	89 a	73 a	100 a	97 a	97 a
Ro-Neet SB + Eptam	4.5 + 2.29	95 a	93 a	82 a	98 a	98 a	98 a
Eptam	3.5	92 a	88 a	73 a	99 a	98 a	98 a
LSD (0.05)		4	6	16	12	16	12

This ‘across years summary’ indicates redroot pigweed and oat control were greatest from Eptam alone or Ro-Neet SB + Eptam and not from Ro-Neet SB alone. With treatments containing Ro-Neet SB + Eptam, increasing the rate of Ro-Neet SB from 2.67 to 4.5 pt/A did not provide a statistical improvement in weed control. However, there was greater sugarbeet injury with Eptam alone or Eptam + Ro-Neet SB as compared to Ro-Neet SB alone (Table 3). Previous research and recommendations indicated tank-mixing Ro-Neet SB + Eptam was a technique to improve grass and broadleaf control and to decrease sugarbeet injury, especially shortly after planting (personal communication with A. Dexter). However, we did not observe improved sugarbeet safety with Ro-Neet SB + Eptam compared to Eptam alone in these trials

EPTAM AND RO-NEET 2019

Sugarbeet injury was least with Ro-Neet SB at 4.5 pt/A or Ro-Neet SB + Eptam at 2.67 + 2.29 pt/A (Table 5). Injury was primarily stature reduction compared to the untreated rows due to delayed emergence. Injury tended to decrease as time progressed but was still evident 28 DAE. However, environmental conditions may have influenced sugarbeet injury. Rainfall was very abundant in July following dry conditions after planting and may have confounded early season stature reduction.

Table 5. Sugarbeet injury 7, 14, and 28 days after emergence (DAE) in 2019.

		Sugarbeet Growth Reduction		
Treatment	Rate	7 DAE	14 DAE	28 DAE
	--pt/A--	---------------------	%	---------------------
Ro-Neet SB	4.5	33 ab	29 a	24 ab
Ro-Neet SB	5.36	51 c	45 b	41 bc
Ro-Neet SB + Eptam	2.67 + 2.29	30 a	28 a	15 a
Ro-Neet SB + Eptam	4.5 + 2.29	44 bc	26 a	26 ab
Eptam	3.5	48 c	35 ab	45 c
Eptam	2.5	43 bc	38 ab	40 bc
LSD (0.05)		12	15	17

We evaluated redroot pigweed, common lambsquarters, foxtail millet and oat control in 2019 (Table 6). Common lambsquarters density was not as uniform as the redroot pigweed and is reflected in the evaluations. Eptam at 2.5 and 3.5 pt/A, Ro-Net SB + Eptam at 4.5 + 2.29 pt/A and Ro-Neet SB + Eptam at 2.67 + 2.29 pt/A provided or tended to provide redroot pigweed control greater than Ro-Neet SB alone 14 DAE. Eptam at both rates provided greater than 90% visible redroot pigweed control 25 DAE (data not presented). Eptam or Ro-Neet SB + Eptam across rates controlled foxtail millet better than Ro-Neet SB alone. No differences in common lambsquarters control were observed from Eptam rate. Eptam alone or Eptam + Ro-Neet SB provided oat control greater than Ro-Neet SB alone. No statistical difference in oat control was observed between Eptam at 2.5 and 3.5 pt/A at either 7 or 14 DAE. Likewise, oat control from Ro-Neet SB + Eptam at 2.67 + 2.29 pt/A was the same as oat control from Ro-Neet SB + Eptam at 4.5 + 2.29 pt/A. Eptam at 3.5 pt/A gave or tended to give better foxtail millet control than Eptam at 2.5 pt/A. Foxtail millet control was best with Eptam alone or Ro-Neet SB + Eptam. Ro-Neet SB at either 4.5 or 5.36 pt/A was more effective at controlling foxtail millet than oat. Eptam was similar efficacy on both foxtail millet and oat.

Table 6. Redroot pigweed, common lambsquarters, foxtail millet, and wild oat control at 7 and 14 days after emergence (DAE) in 2019.

		7 DAE				14 DAE			
Treatment	Rate	rrpw[a]	colq	fxmi	oat	rrpw	colq	fxmi	oat
	--pt/A--		----------------------------------			%	---------------------------------		
Ro-Neet SB	4.5	65 c	50 b	81 bc	43 c	66 c	84	96 b	48 c
Ro-Neet SB	5.36	70 bc	81 a	80 c	53 b	78 b	88	96 b	63 b
Ro-Neet SB + Eptam	2.67 + 2.29	88 a	75 ab	89 ab	89 a	88 ab	90	98 ab	96 a
Ro-Neet SB + Eptam	4.5 + 2.29	91 a	85 a	89 a	90 a	91 a	93	97 ab	95 a
Eptam	3.5	87 a	81 a	92 a	93 a	92 a	92	99 a	97 a
Eptam	2.5	76 b	80 a	80 c	85 a	87 ab	91	99 a	96 a
LSD (0.05)		9	18	8	8	11	NS	2	4

[a]Weed species abbreviations (left to right): rrpw=redroot pigweed, colq=common lambsquarters, fxmi=foxtail millet.

References

Dale TM, Renner KA, Kravchenko AN (2006) Effect of herbicides on weed control and sugarbeet (Beta vulgaris) yield and quality. Weed Sci 20:150-156

Luecke JL and Dexter AG (2003) Survey of weed control and production practices on sugarbeet in eastern North Dakota and Minnesota. Sugarbeet Res Ext Rep. 33:35-38

Soltani N, Dille A, Robinson DE, Sprague CL, Morishita DW, Lawrence NC, Kniss AR, Jha P, Felix J, Nurse RE, and Sikkema PH (2018) Potential yield loss in sugar beet due to weed interference in the United States and Canada. Weed Technol 32:749-753

SUGARBEET TOLERANCE AND WEED CONTROL FROM POSTEMERGENCE ETHOFUMESATE 4SC

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INTRODUCTION

Sugarbeet (*Beta vulgaris* L.) is a high value, root crop with approximately 18% sucrose content in the root (Milford 2006). Weed control is an important component in profitability of sugarbeet production (Soltani et al. 2018). Weeds can also affect sugarbeet quality by reducing sucrose percentage and decreasing the aesthetics of production fields. Ethofumesate is a broad spectrum, soil-applied herbicide for control of broadleaf and grass weeds in sugarbeet (Edwards et al. 2005). Some weed species controlled with ethofumesate are common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), barnyardgrass (*Echinochloa crus-galli*), and wild oat (*Avena fatua* L.), which are known to reduce yield in sugarbeet (Ekins and Cronin 1972). Ethofumesate is a commonly used soil-applied herbicide, however, it can be applied postemergence at 12 fl oz/A. Generic Crop Science has developed a new Ethofumesate 4SC label that increases postemergence use rates from 12 to 128 fl oz/A to sugarbeet with greater than two true leaves. Field and greenhouse experiments were conducted in 2018 and 2019 to evaluate sugarbeet tolerance and herbicide efficacy.

MATERIALS AND METHODS

SUGARBEET TOLERANCE

Experiments were conducted near Downer, MN, Hickson, ND, Horace, ND and Prosper, ND in 2018 and Crookston, MN, Hickson, ND, Prosper, ND, and Wolverton, MN in 2019. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted between May 3 and June 7 across 2018 and 2019.

Herbicide treatments were applied when sugarbeet was at the 2-lf stage with a bicycle wheel 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 long. Treatments consisted of one application of ethofumesate at 0, 8, 16, 32, 64, and 128 fl oz/A. All treatments contained Destiny HC at 1.5 pt/A which was provided by Winfield United.

Sugarbeet injury was evaluated as a visual estimate of percent growth reduction of the middle 4 rows per plot compared to the adjacent 2 untreated rows. Sugarbeet was harvested from the center two rows of the four treated rows within a plot in the fall and assessed for yield and quality. Yield components were analyzed using SAS Data Management software PROC MIXED procedure to test for significant differences at p=0.05. Experimental design was randomized complete block with 6 replications.

ETHOFUMESATE EFFICACY

Experiments were conducted on indigenous populations of common lambsquarters, redroot pigweed, and waterhemp in sugarbeet grower fields near Moorhead, Lake Lillian, and Oslo, Minnesota and Minto and Prosper, North Dakota in 2018 and 2019. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted between May 7th and 15th in both years.

Herbicide treatments were applied at the 2-lf sugarbeet stage. 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 40 feet in length.

Sugarbeet injury and weed control was evaluated. 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 four replications. Data were analyzed with the ANOVA procedure of ARM, version 2019.4 software package.

RESULTS

SUGARBEET TOLERANCE

Sugarbeet stature reduction ranged from 0 to 28% 7 DAT (days after treatment) and 0 to 29% 14 DAT (Table 1). Stature reduction increased as ethofumesate rate increased from 8 to 128 fl oz/A. Ethofumesate at 8 and 16 fl oz/A had similar stature to the untreated check at 7, 14 and 28 DAT. Ethofumesate at 32 fl oz/A had slightly reduced stature compared to the untreated check at 7 and 14 DAT but had grown out of the injury and looked similar to the untreated check at 28 DAT. Ethofumesate at 64 and 128 fl oz/A had greater injury compared to the untreated check at 7, 14 and 28 DAT. Visible stature reduction tended to decrease throughout the growing season.

Table 1. Stature reduction in response to Ethofumesate 4SC rate across 7 environments in 2018-2019[a].

Ethofumesate[b]	**7 DAT[c]**	**14 DAT**	**28 DAT**
--fl oz/A--	-------------------% stature reduction-------------------		
0	0 a	0 a	0 a
8	2 a	1 a	0 a
16	2 a	2 a	1 a
32	7 b	6 b	2 a
64	16 c	14 c	8 b
128	28 d	29 d	18 c
LSD (0.05)	**5**	**5**	**4**
	------------------*P*-value-------------------		
	<0.0001	<0.0001	<0.0001

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[b]High surfactant methylated oil concentrate at 1.5 pt/A added to each post treatment.
[c]Stature reduction 7 and 14 days after treatment (DAT).

Sugarbeet root yield and sucrose content were not affected by ethofumesate rate, however, recoverable sucrose content generally decreased as ethofumesate rate increased (Table 2). Ethofumesate decreased recoverable sucrose content at 128 fl oz/A to 8,024 lbs/A compared to the untreated check at 8,484 lbs/A. While ethofumesate at 64 fl oz/A numerically decreased recoverable sucrose per acre, it was still statistically comparable to the untreated check. Root yield and sucrose content was an average of 30 tons/A and 15.6% across all treatments and environments.

Table 2. Root yield, recoverable sucrose, and sucrose content in response to Ethofumesate 4SC rate across 7 environments in 2018-2019.[a]

Ethofumesate[b]	**Root Yield[c]**	**Sucrose Content**	**Rec. Suc[d]**
--fl oz/A--	---Tons/A---	---%---	---lbs/A---
0	30	15.7	8,484 ab
8	30	15.6	8,343 abc
16	30	15.7	8,440 ab
32	31	15.7	8,511 a
64	29	15.7	8,143 bc
128	29	15.4	8,024 c
LSD (0.05)	**NS**	**NS**	**349**
	-------------------------*P*-value-----------------------		
	0.1703	0.2844	0.0410

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[b]High surfactant methylated oil concentrate at 1.5 pt A added to each post treatment.
[c]Root yield reported in tons per acre.
[d]Recoverable sucrose reported in pounds per acre.

Ethofumesate reduced sugarbeet stature at rates greater or equal to 32 fl oz/A, however, stature reduction decreased as time progressed. Sugarbeet stature and yield components were negatively affected by rates of ethofumesate of 64 fl oz/A or greater.

ETHOFUMESATE EFFICACY RESULTS

Visible common lambsquarters control ranged from 43 to 100% when herbicide treatments were evaluated 7 DAT and from 26-96% 14 DAT (Table 3). Glyphosate alone gave 98 and 95% control 7 and 14 DAT, respectively. While ethofumesate at 32 and 64 fl oz/A plus glyphosate provided 100% numerical common lambsquarters control 7 DAT, adding ethofumesate with glyphosate did not significantly improve common lambsquarters control compared to glyphosate alone.

Common lambsquarters control from ethofumesate generally increased as the ethofumesate rate increased. Common lambsquarters control from 32 fl oz/A ethofumesate was greater at 7 and 14 DAT than control from 16 fl oz/A ethofumesate. However, increasing the rate from 32 to 64 or 128 fl oz/A did not consistently improve common lambsquarters control.

Table 3. Common lambsquarters visible control 7 and 14 DAT across 10 environments[a] in 2018 and 2019.

		Common Lambsquarters	
Treatment	**Rate**	**7 DAT**	**14 DAT**
	----fl oz/A----	--------------%---------------	
Glyphosate	32	98 a	95 a
Ethofumesate	16	48 e	45 e
Ethofumesate	32	70 cd	66 d
Ethofumesate	64	64 d	77 bcd
Ethofumesate	128	79 bc	84 abc
Ethofumesate + glyphosate	32 + 32	100 a	96 a
Ethofumesate + glyphosate	64 + 32	100 a	95 a
LSD (0.05)		**13**	**16**
		------------*P*-value-------------	
		<0.0001	<0.0001

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

Visible redroot pigweed control ranged from 32 to 100% when evaluated 7 DAT and 15 to 98% when evaluated 14 DAT (Table 4). Ethofumesate alone at rates ranging from 16 to 128 fl oz/A controlled 44 to 64 and 47 to 76% redroot pigweed 7 and 14 DAT, respectively. Redroot pigweed control was greater at 32 fl oz/A ethofumesate alone compared to 16 fl oz/A, 14 DAT, but control did not significantly increase as the ethofumesate rate increased.

Glyphosate alone or with ethofumesate at 32 or 64 fl oz/A provided the greatest redroot pigweed control 7 and 14 DAT, however, the addition of ethofumesate did not improve redroot pigweed control compared to the glyphosate alone at 7 DAT. Glyphosate plus ethofumesate at 32 or 64 fl oz/A tended to be better than glyphosate alone 14 DAT, suggesting the residual control benefit of mixing ethofumesate with glyphosate. Ethofumesate at 32 fl oz/A combined with glyphosate provided redroot pigweed control similar to ethofumesate at 64 fl oz/A combined with glyphosate at both 7 and 14 DAT.

Visual waterhemp control ranged from 46 to 91% and from 31 to 91% at 7 and 14 DAT, respectively (Table 5). Waterhemp control from glyphosate was 62% at 7 DAT and 53% at 14 DAT suggesting waterhemp were glyphosate resistant biotype. Ethofumesate tended to increase waterhemp control as ethofumesate rate increased. This was observed at both 7 and 14 DAT.

Waterhemp control from 64 or 128 fl oz/A ethofumesate was better than control from 16 fl oz/A ethofumesate at 7 DAT. Waterhemp control from 128 fl oz/A ethofumesate was better than 16 or 32 fl oz/A ethofumesate at 14 DAT. Ethofumesate tended to improve waterhemp control 14 DAT compared to 7 DAT, suggesting residual control. There was no difference in waterhemp control between 32 or 64 fl oz/A ethofumesate plus glyphosate at either 7 or 14

DAT. Although ethofumesate alone at 128 fl oz/A provided similar waterhemp control as compared to glyphosate plus ethofumesate, applying ethofumesate alone at 64 or 128 fl oz/A may not be an effective strategy due to less sugarbeet tolerance at higher ethofumesate rates and increased input costs from high rates of ethofumesate compared to lower rates of ethofumesate mixed with glyphosate. Glyphosate applied with ethofumesate also provides greater control of other broadleaf weeds in fields including redroot pigweed and common lambsquarters in addition to potentially controlling germinating waterhemp with susceptible alleles.

Table 4. Redroot pigweed visible control 7 and 14 DAT across 10 environments[a] in 2018 and 2019.

		Redroot Pigweed	
Treatment	**Rate**	**7 DAT**	**14 DAT**
	----fl oz/A----	-------------%--------------	
Glyphosate	32	99 a	93 ab
Ethofumesate	16	44 fg	47 e
Ethofumesate	32	50 ef	62 d
Ethofumesate	64	54 def	71 cd
Ethofumesate	128	64 cd	76 cd
Ethofumesate + glyphosate	32 + 32	99 a	98 a
Ethofumesate + glyphosate	64 + 32	100 a	99 a
LSD (0.05)		**10**	**14**
		-------------*P*-value-----------	
		<0.0001	<0.0001

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

Table 5. Waterhemp visible control 7 and 14 DAT across 10 environments[a] in 2018 and 2019.

		Waterhemp	
Treatment	**Rate**	**7 DAT**	**14 DAT**
	----fl oz/A----	---------------%----------------	
Glyphosate	32	62 bcd	53 cd
Ethofumesate	16	58 cd	65 bcd
Ethofumesate	32	63 bcd	66 bc
Ethofumesate	64	74 abc	78 ab
Ethofumesate	128	80 ab	84 a
Ethofumesate + glyphosate	32 + 32	86 a	86 a
Ethofumesate + glyphosate	64 + 32	91 a	91 a
LSD (0.05)		**18**	**16**
		-----------*P*-value------------	
		0.0001	<0.0001

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

SUMMARY

Ethofumesate 4SC applied postemergence at rates from 8 to 128 fl oz/A did not influence sugarbeet density, root yield, or sucrose content. However, Ethofumesate 4SC significantly reduced recoverable sucrose and sugarbeet stature at 128 fl oz/A when sugarbeet tolerance experiments were combined across locations in 2018 and 2019.

Ethofumesate is not a stand-alone postemergence herbicide for common lambsquarters, redroot pigweed, or waterhemp control, however, ethofumesate can increase efficacy of postemergence glyphosate applications. Results suggest a mixture of ethofumesate at 32 fl oz/A plus glyphosate applied early POST can improve burndown and residual control of common lambsquarters, redroot pigweed, and waterhemp compared to ethofumesate or glyphosate alone. However, similar control from glyphosate alone was observed in common lambsquarters and redroot pigweed. Benefits of adding ethofumesate to an early POST glyphosate application may not become apparent until later in the growing season. Benefits of ethofumesate may not be observed if application is not timed to an activating rainfall. Additional research may be conducted to evaluate two-spray programs of glyphosate and ethofumesate.

References

Edwards D, Zinn N, Prieto R, Wyatt TJ, Brown L, Al-Mudallal A, et al. (2005) Reregistration eligibility decision for ethofumesate. Environmental Protection Agency. 738-R-05-010. https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-110601_1-Sep-05.pdf. Accessed: September 26, 2017

Ekins WL, Cronin CH (1972) NC 8438, a promising new broad spectrum herbicide for sugarbeet. J Amer Soc of Sugar Beet Technol 17:134-143

Milford GFJ (2006) Plant structure and crop physiology. Page 30 in Draycott AP ed. Sugarbeet. United Kingdom: Blackwell Publishing Ltd

Soltani N, Dille A, Robinson DE, Sprague CL, Morishita DW, Lawrence NC, Kniss AR, Jha P, Felix J, Nurse RE, and Sikkema PH (2018) Potential yield loss in sugar beet due to weed interference in the United States and Canada. Weed Tech 32:749-753

HERBICIDE TOLERANCE TRAIT IN SOYBEAN: FLEXIBILITY OR COMPLEXITY

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SUMMARY

1. The herbicide treatment used with herbicide traits is more important than trait and respective herbicide(s) applied with the trait.
2. Herbicide traits are opportunities for improved control of troublesome weeds when the herbicide treatment fails to provide control or deliver multiple effective herbicides.
3. Use both effective PRE and timely POST applications to manage weeds, regardless of the herbicide or herbicide trait.

INTRODUCTION

Weeds continue to concern sugarbeet producers (Soltani et al. 2018). Sugarbeet is a poor competitor with weeds from emergence to canopy closure (Cattanach et al. 1991). Sugarbeet cotyledons are small, lack vigor, and take roughly two months to shade ground between rows, thus providing ample time for weeds to establish and compete. Limited weed control options and herbicide resistance places sugarbeet at a disadvantage compared to other row crops (Soltani et al. 2018). A strategy to aid weed control in sugarbeet is to maximize weed management in the crop sequence with sugarbeet. Crop rotations introduces growth cycle diversification thus changing inputs including pesticides (Liebman and Dyck 1993) and changing weed spectrum and pressure resulting in increased crop yield (Peterson and Varvel 1989). Crop sequences across the region and cooperatives (Southern Minnesota Beet Sugar Cooperative, Minn-Dak Farmers' Cooperative, and American Crystal Sugar Company) all include soybean. Soybean producers in the United States, particularly in the Midwest, list waterhemp as one of their most troublesome weeds to control (Soltani et al. 2009). Waterhemp growth characteristics, including extended emergence patterns, cause waterhemp escapes since waterhemp may germinate, emerge, and produce seed after the producer has completed his/her weed control program.

Herbicide tolerant trait technologies, including Xtend and Liberty Link, have created POST herbicide options creating effective option for control of late germinating waterhemp in soybean, thus reducing seed in the soil seed bank while improving herbicide diversification throughout crop sequence with sugarbeet. The objective of this experiment was to evaluate herbicide treatments and trait technologies in soybean by considering waterhemp and common lambsquarters control, crop rotation flexibility, herbicide diversity, and cost. Our hypotheses is a weed management plan delivering multiple effective herbicides for lambsquarters and waterhemp control will improve overall control. Second, effective weed control can be achieved with multiple herbicide trait technologies thus providing opportunity for improved profitability. The question for producers is selecting a herbicide trait technology the first or last step in finalizing the weed management plan in soybean.

MATERIALS AND METHODS

An experiment was conducted near Moorhead, MN in 2019. The experimental area was prepared for planting using a Kongskilde s-tine field cultivator on May 9, 2019. ND Stutsman conventional, AG0934 Roundup Ready2, S150097 LibertyLink, and AG07X9 Roundup Ready 2 Xtend soybean were planted in 22-inch rows at 160,000 seeds per acre on May 30 with a John Deere 1700XP 6-row planter. Herbicide trait technologies represent some of the many traits available to MN and ND producers in soybean (Table 1).

Experimental design was randomized complete block with four replications for each trial. Treatment arrangement was a two-factor factorial; factors being herbicide treatment and herbicide trait technology. PRE, EPOST, and POST herbicides were applied immediately after planting on May 31, June 19, and July 1, respectively. Herbicide treatment was a soil residual herbicide applied as single herbicide, a mixture, or PRE, and a soil residual herbicide EPOST followed by the herbicide conforming to the herbicide trait (i.e. Liberty applied to LibertyLink soybean) (Table 2). FlexStar was applied POST over conventional soybean. All herbicide treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 30 feet in length. Environmental conditions at application are indicated in Table 3.

Table 1. Soybean herbicide-resistance traits and herbicides that can be used in combination with resistant traits. A checkmark indicates that soybean herbicide trait packages have resistance to various herbicide products.[a]

Soybean Herbicide Trait	Glyphosate	Glufosinate	2,4-D Choline[b]	Dicamba[c]	HPPD Inhibitors[d]
Conventional	✔				
Glyphosate Tolerant (GT)	✔				
Roundup Ready[e]	✔				
Roundup Ready 2 Yield[e]	✔				
Roundup Ready 2 Yield Xtend[e]	✔			✔	
Roundup Ready 2 Yield Xtendflex[e]	✔	✔		✔	
LibertyLink (LL)		✔			
LLGT27d	✔	✔			✔
Enlist	✔		✔		
Enlist E3	✔	✔	✔		
GT27	✔				✔

[a] Always consult herbicide labels for application requirements.
[b] Only approved 2,4-D choline formulations (Enlist Duo, Enlist One) are permitted for over-the top applications to Enlist and Enlist E3 soybeans.
[c] Only approved dicamba formulations (Engenia, FeXapan, Tavium, XtendiMax) are permitted for over-the-top application to Xtend and XtendFlex soybeans.
[d] GT27 and LLGT27 are resistant to isoxaflutole pre-emergence. No HPPD-inhibiting herbicide is approved for use in soybeans in the U.S. as of January 2020.
[e] Always consult herbicide label to determine if glyphosate formulation is approved for RR soybeans.
[f] Not approved for commercial production in the U.S. as of January 2020.

Table 2. Herbicide treatment in soybean

Herbicide treatment	Timing
Valor / Trait	PRE / POST
Valor[a] + Zidua / Trait	PRE / POST
Valor + Zidua / chloroacetamide[b] / Trait	PRE / EPOST /POST
Valor + Zidua + metribuzin / chloroacetamide / Trait	PRE / EPOST /POST

[a]Valor or Engenia, depending on seed trait
[b]Dual Magnum, Outlook, or Warrant depending on seed trait

Table 3. Application Information – Moorhead, MN 2019

Date	May 31	June 19	July 1
Time of Day	2:30 PM	1:00 PM	11:00 AM
Air Temperature (F)	79	76	77
Relative Humidity (%)	30	44	57
Wind Velocity (mph)	8	2	4
Wind Direction	N	SE	N
Soil Temp. (F at 6”)	65	66	70
Soil Moisture	Fair	Good	Good
Cloud Cover (%)	0	90	50
Next Rainfall	June 8	June 20	July 3

Soybean Stage	PRE	1 Trifoliolate	2 Trifoliolate
Common lambsquarters	0 in	3 in	9 in
Redroot Pigweed	0 in	2 in	9 in
Waterhemp	0 in	2 in	9 in

Soybean injury and common lambsquarters and waterhemp control described in this report were evaluated on June 26, July 15, and 25, 2019. All soybean injury and weed control evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Data were analyzed with the ANOVA procedure of ARM, version 2019.4, software package.

RESULTS

Visible soybean injury from herbicide treatments was negligible 26 DAP (days after planting) but increased to 40% when Liberty followed Fierce MTZ and Outlook 30 DAT (days after treatment) (70 DAP) (Tables 4-7). Soybean injury increased when either Zidua, metribuzin or a chloroacetamide herbicide was combined with Valor or Engenia. Soybean injury may have been exacerbated by Iron Deficiency Chlorosis (IDC) which increased soybean injury especially from Valor or Valor plus Zidua (Fierce) plus a chloroacetamide herbicide or Valor, Fierce, and metribuzin combined with the chloroacetamide herbicide. Soybean injury generally was not influenced by Flexstar, PowerMax, or Liberty applied with their respective herbicide trait technology POST.

Table 4. Soybean injury and common lambsquarters and waterhemp control in response to herbicide treatment in conventional soybean, Moorhead MN, 2019.

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Treatment	**Rate**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
	oz/A	%	%	%	%
Valor / Flexstar	2.5 / 12	3	3 c	45	98
Fierce / Flexstar	3 /12	0	16 b	68	99
Fierce + Dual Magnum / Flexstar	3 / 16 / 12	8	29 ab	45	99
Fierce MTZ + Dual Magnum / Flexstar	16 / 16 / 12	3	35 a	65	99
P-Value		0.3076	0.0011	0.2409	0.5896

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) or 70 DAP.
[c]Control 38 DAT or 78 DAP.

Table 5. Soybean injury and common lambsquarters and waterhemp control in response to herbicide treatment in Xtend soybean, Moorhead MN, 2019.

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Treatment	**Rate**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
	oz/A	%	%	%	%
Engenia / PowerMax	12.8 / 32	0	9 b	97	68
Engenia + Zidua / PowerMax	12.8 + 2.1 / 32	3	15 b	99	73
Engenia + Zidua / Warrant / PowerMax	12.8 + 2.1 / 40 / 32	0	31 a	99	83
Engenia + Zidua + Metribuzin / Warant / PowerMax	12.8 + 2.1+ 5 / 40 / 32	3	33 a	99	85
P-Value		0.4363	0.0355	0.4363	0.0623

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) or 70 DAP.
[c]Control 38 DAT or 78 DAP.

Common lambsquarters and waterhemp control was influenced by both herbicide treatment and herbicide with its respective herbicide tolerant trait (Tables 4-7). Some POST herbicide treatment and seed trait options provided over 95% lambsquarters and / or waterhemp control regardless of soil applied herbicides regardless of soil residual herbicide. For example, waterhemp control from FlexStar POST applied with conventional soybean, lambsquarters control from PowerMax POST applied with Xtend soybean and common lambsquarters and waterhemp control from Liberty POST applied with LibertyLink soybean provided 95% or greater control regardless of the soil residual herbicides.

Some soil applied herbicides mixtures improved lambsquarters or waterhemp control. For example, Fierce, Fierce plus metribuzin (Fierce MTZ), or Fierce MTZ and Dual Magnum EPOST fb PowerMax POST with RR2 soybean controlled greater than 95% lambsquarters compared to Valor PRE followed by PowerMax POST alone. Likewise, Fierce or Fierce MTZ and Dual Magnum EPOST followed by PowerMax POST provided greater than 95% waterhemp control compared to Valor or Fierce fb PowerMax POST with RR2 soybean.

Table 6. Soybean injury and common lambsquarters and waterhemp control in response to herbicide treatment in LibertyLink soybean, Moorhead MN, 2019.

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Treatment	**Rate**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
	oz/A	%	%	%	%
Valor / Liberty	2.5 / 32	0	21 b	95	92 b
Fierce / Liberty	3 /32	3	26 b	96	98 a
Fierce + Outlook / Liberty	3 / 10 / 22	0	37 a	95	99 a
Fierce MTZ + Outlook / Liberty	16 / 10 / 32	0	40 a	95	99 a
P-Value		0.4363	0.0354	0.9838	0.0495

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.
[c]Control 38 DAT or 78 DAP.

Table 7. Soybean injury and common lambsquarters and waterhemp control in response to herbicide treatment in Roundup Ready soybean, Moorhead MN, 2019.

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide treatment	**Rate**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
	oz/A	%	%	%	%
Valor / PowerMax	2.5 / 32	0	13 b	88	69 b
Fierce / PowerMax	3 /32	0	28 a	99	86 a
Fierce + Dual Magnum / PowerMax	3 / 16 / 32	0	36 a	98	97 a
Fierce MTZ + Dual Magnum / PowerMax	16 / 16 / 32	5	37 a	97	96 a
P-Value		0.4363	0.0003	0.4326	0.0020

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.
[c]Control 38 DAT or 78 DAP.

Some herbicide and seed trait combinations did not provide 95% lambsquarters and waterhemp control. For example, Valor, Fierce, Fierce followed by (fb) Dual Magnum or Fierce MTZ fb Dual Magnum EPOST and followed by Flexstar POST failed to provide acceptable lambsquarters control. Likewise, Engenia (dicamba) substituted for Valor and followed by PowerMax POST failed to provide acceptable waterhemp control.

Table 8. Soybean injury and common lambsquarters and waterhemp control in response to Valor at 2.5 oz/A or Engenia at 12.8 fl oz/A PRE across herbicide traits in soybean, Moorhead MN, 2019.

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Trait	**Herbicide**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
		%	%	%	%
Conventional	Valor	3	8 b	45 b	98 a
Xtend	Engenia	0	9 b	97 a	68 b
LibertyLink	Valor	0	21 a	95 a	92 ab
Roundup Ready	Valor	0	13 b	88 a	79 ab
Average		1	13	81	84
P-Value		0.4363	0.0003	0.0008	0.0312

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.
[c]Control 38 DAT or 78 DAP.

Table 9. Soybean injury and common lambsquarters and waterhemp control in response to Fierce at 3 oz/A or Engenia plus Zidua SC at 12.8 fl oz + 2.1 oz/A PRE across herbicide traits in soybean, Moorhead MN, 2019[a].

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Trait	**Herbicide**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
		%	%	%	%
Conventional	Fierce	0	16	68 b	99 a
Xtend	Engenia + Zidua SC	3	15	99 a	73 b
LibertyLink	Fierce	3	26	96 a	98 a
Roundup Ready	Fierce	0	28	99 a	86 ab
Average		2	21	91	89
P-Value		0.4363	0.0759	0.0166	0.0223

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.
[c]Control 38 DAT or 78 DAP.

Soybean injury and common lambsquarters and waterhemp data was analyzed by herbicide treatment across herbicide trait technologies (Tables 8-11). Once again, soybean injury 26 DAP was negligible but increased and ranged from 8 to 39%, depending on herbicide treatment and herbicide trait 30 DAT / 78 DAP. Soybean injury tended to increase when Zidua, a chloroacetamide herbicide or metribuzin was combined with Valor (Figure 1).

Common lambsquarters and waterhemp control was dependent on herbicide treatment, herbicide trait, and respective POST herbicide (Tables 8-11). For example, lambsquarters and waterhemp control averaged across POST herbicides following Valor PRE provided 81% and 84% control, respectively (Figure 1) which is less than desirable.

Table 10. Soybean injury and common lambsquarters and waterhemp control in response PRE followed by EPOST treatments across herbicide traits in soybean, Moorhead MN, 2019[a].

		Growth Reduction		Lambsquarters	Waterhemp
Herbicide Trait	**Herbicide**	**26 DAP[a]**	**30 DAT[b]**	**38 DAT[c]**	**38 DAT**
		%	%	%	%
Conventional	Fierce / Dual Magnum	8	29	45 b	99 a
Xtend	Engenia + Zidual SC / Warrant	0	25	99 a	83 b
LibertyLink	Fierce / Outlook	0	31	95 a	99 a
Roundup Ready	Fierce / Dual Magnum	0	29	98 a	97 a
Average		2	29	84	95
P-Value		0.1298	0.8085	0.0001	0.0066

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.
[c]Control 38 DAT or 78 DAP.

Table 11. Soybean injury and common lambsquarters and waterhemp control in response PRE followed by EPOST and POST treatments across herbicide traits in soybean, Moorhead MN, 2019[a].

Herbicide Trait	Herbicide	Growth Reduction		Lambsquarters	Waterhemp
		26 DAP[a]	30 DAT[b]	38 DAT[c]	38 DAT
		%	%	%	%
Conventional	Fierce MTZ / Dual Magnum	3	35	65 b	99
Xtend	Engenia + Zidual SC + metribuzin / Warrant	3	29	99 a	85
LibertyLink	Fierce MTZ / Outlook	0	39	95 a	99
Roundup Ready	Fierce MTZ / Dual Magnum	5	39	97 a	96
Average		4	36	89	95
P-Value		0.6915	0.2477	0.0011	0.0515

[a]Growth reduction 26 days after planting (DAP).
[b]Growth reduction 30 days after treatment (DAT) and 70 DAP.

However, embedded within these averages, Valor fb Flexstar with conventional soybean provided 98% waterhemp control and Engenia fb PowerMax with Xtend soybean provided 97% common lambsquarters control and highlighting the need to review specific herbicide and trait combinations. We observed the same outcome when lambsquarters and waterhemp control was averaged across POST herbicides following more complex treatments. We believe lambsquarters and waterhemp control, in general, improved with more complex herbicide treatments since the number of effective herbicides in the treatment increased.

Effective herbicides were determined by considering weed control scores assigned to herbicides using the 2020 ND Weed Control Guide (Table 12). Herbicide treatment must provide 'good' or 'excellent' control for treatment to be considered an effective herbicide. Value in table is cumulative score for herbicides representing the treatment. In general, mixtures or sequential treatments increased the number of effective herbicides. Target should be a herbicide treatment delivering two or three effective herbicides. We believe greater than three effective herbicides is excessive but might be required for broad spectrum control.

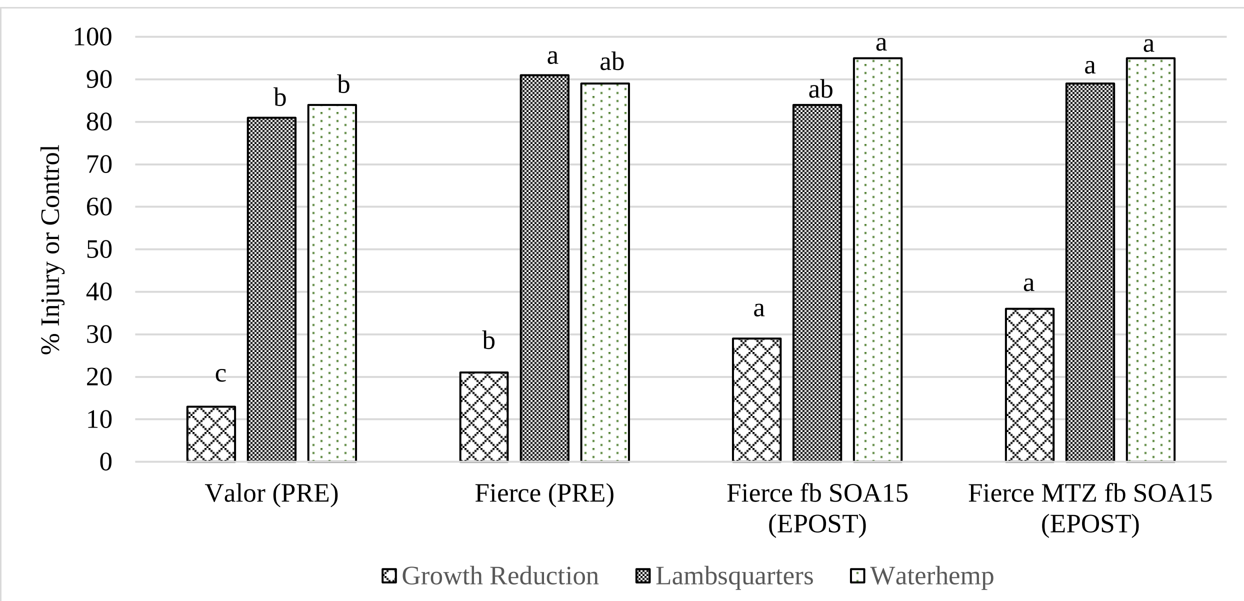

Figure 1. Soybean injury and common lambsquarters and waterhemp control in response to herbicide treatment averaged across herbicide trait, Moorhead MN, 2019.

Table 12. Effective sites of action against common lambsquarters or waterhemp.[a]

Herbicide Treatment	Flexstar		Roundup		LibertyLink		Xtend[b]		Avg.
	LQ[a]	**WH**	**LQ**	**WH**	**LQ**	**WH**	**LQ**	**WH**	
Valor	1	2	2	1	2	2	2	1	1.6
Fierce (Valor + Zidua)	1	3	2	2	2	3	2	2	2.1
Fierce / chloroacetamide	1	4	2	3	2	4	2	3	2.6
Fierce MTZ / chloroacetamide	1	5	2	4	2	5	2	4	3.1

[a]Abbreviation: LQ= common lambsquarters; WH= waterhemp; Avg = average.
[b]Includes glyphosate or dicamba.

We were interested in profitability plotted against performance metrics. Profitability was calculated by subtracting cost of the herbicide treatment and soybean seed plus trait technology fee from an estimate of revenue. Revenue was estimated simply as the average soybean yield in Cass county by $8.35 soybean per bushel. No application cost estimates were included since we applied herbicides using our owned equipment.

Performance metrics considered were less than 30% soybean injury (1 point), greater than 95% lambsquarters (1 point) and waterhemp control (1 point) and treatments containing at least two (1 point) or three (2 point) effective herbicides against lambsquarters or waterhemp.

The data suggests greater cost (less profitability) with treatments delivering more effective herbicides or treatments providing broad spectrum weed control. However, a more detail review of the analysis reveals that profitability is not as simple as selecting the cheapest trait. Profitability is a function of understanding your most important weed control needs for a field and matching it up against herbicide treatments and possible crop rotation restrictions that one may have depending on your crop sequence.

In my opinion, the take home message of this experiment is that while the new herbicide resistant traits provide opportunities for improved waterhemp or lambsquarters management, the herbicide system used with these traits is more important than the individual trait or their respective herbicide. This experiment emphasizes the importance of using both effective PRE and timely POST applications to manage waterhemp and / or lambsquarters, regardless of the herbicide or trait.

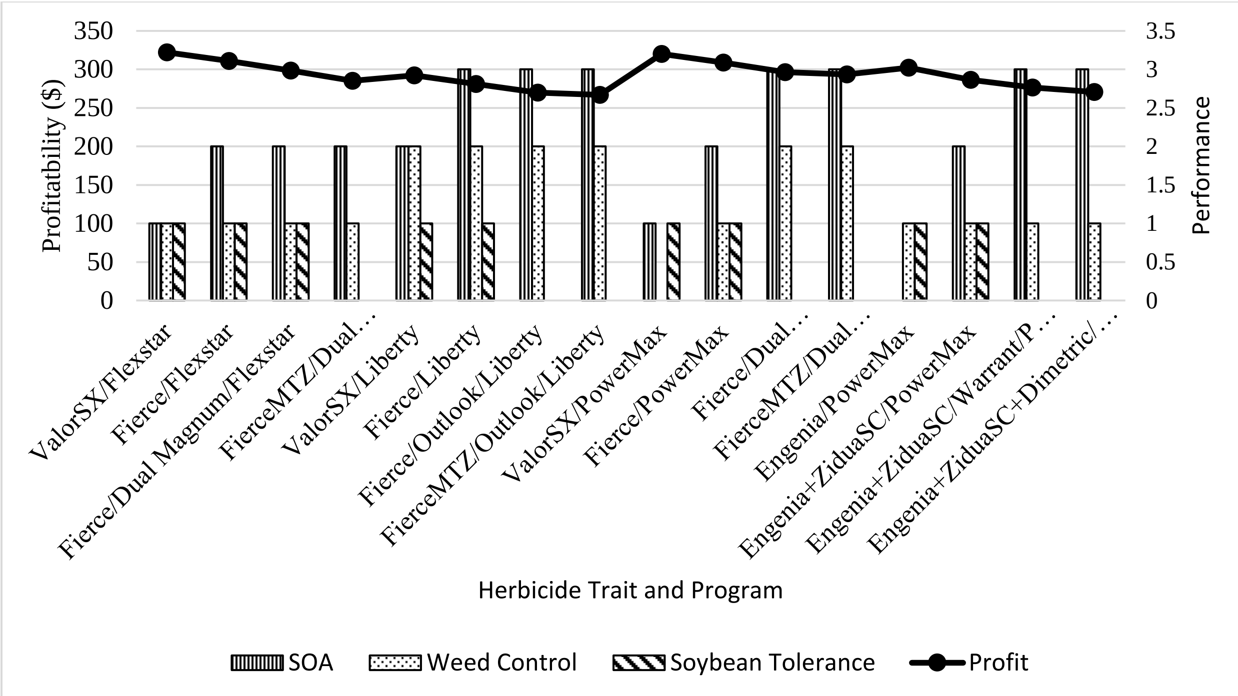

Figure 2. Herbicide treatment and trait performance plotted against profit (revenue minus herbicide treatment and trait cost)

CONCLUSIONS

Herbicide treatments (mixtures or PRE fb POST combinations) provided greater than 95% lambsquarters and waterhemp control. Herbicide mixtures usually provide multiple effective sites of action. Herbicide traits use strategically solve field specific weed control challenges. Finally, profitability is more complex than simply plotting the cost of herbicide treatment and herbicide trait.

References

1. Cattanach AW, Dexter AG, Oplinger ES (1991) Sugarbeets. Alternative Field Crops manual. Madison: University of Wisconsin Cooperative Extension.
2. Liebman M and Dyck E (1993) Crop rotation and intercropping strategies for weed management. Ecological Society of America. 3(1):92-122
3. Peterson TA and Varvel GE (1989) Crop yield as affected by rotation and nitrogen rate. I. soybean. Agronomy Journal. 81:727-731
4. Soltani N, Vyn JD, Sikkema PH (2009) Control of common waterhemp (*Amaranthus tuberculantus* var. *rudis*) in corn and soybean with sequential herbicide applications. Can. J. Plant Sci. 89:127-132
5. Soltani N, Dille A, Robinson DE, Sprague CL, Morishita DW, Lawrence NC, Kniss AR, Jha P, Felix J, Nurse RE, and Sikkema PH (2018) Potential yield loss in sugar beet due to weed interference in the United States and Canada. Weed Technol 32:749-753

SOIL MANAGEMENT PRACTICES

NOTES

INTER-SEEDING OF COVER CROPS UNDER SUGARBEET

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INTRODUCTION

Wind/water erosion are responsible for soil loss in the Red River Valley (RRV). Fields with crops having minimum residue cover after harvest are particularly prone to erosion. Consequently, the crops planted on these soils face the damage or even occasional re-seeding is necessary if the spring wind occurs before the seedlings become large enough to resist the wind and water damage. After the harvest few leaves or groundcover remain to protect the soil from wind and water erosion. Sugarbeet crops (especially sugarbeet seedlings) are negatively affected from wind storms in several aspects. Damage ranges from minimal to complete and can result in a need to re-seed the entire fields. Re-planting particularly can cause great economic loss particularly when Roundup Ready sugarbeet seed are used and there's a short window left for crop establishment. On the top, increased fluctuation in climate with frequent drought and severe, localized rainstorm events in the region has accelerated the effect.

Cover cropping practices have become more widely adopted in the RRV as a way to reduce soil loss from wind and flood events. The following criteria are some of the most important for selecting a cover crop for sugarbeet production in the RRV; holds soil in place with a sufficiently developed root system, reduces wind damages to young seedlings with its aboveground biomass, is inexpensive, and can be managed and killed so that it does not compete with the crop for nutrients, water, and light. But establishing cover crops in RRV is not without its challenges. There's a little growing season left after the harvest (Sept-Nov), it often limits the ability to get a good cover stand. As a solution, we hypothesized that inter-seeded cover crop will produce more biomass, and its root will protect the soil from erosion during fall and early spring. So this research is focused on identifying the effects of interseeding cover crop species and best time to plant these cover crops and how these interaction, effect sugarbeet yield and quality. This will help growers to determine which cover crop species and planting date is most promising for incorporation into the sugarbeet cropping system. With this, RRV sugarbeet growers can find appropriate species and interseeding time for off-setting the extra time, effort, and expense involved in the work of planting and managing the crops.

METHODS

Field study was conducted at two sites; Ada, MN and Prosper, ND. The experiment was laid out in factorial RCBD which included four different cover crops inter-seeded at two planting date; check (no cover crop), winter rye (*Secale cereal* L.)cv. ND Dylan, winter camelina (*Camelina sativa* L.) cv. Joelle, winter Austrian pea (*Pisum Sativum* L.), mustard (*Sinapis alba* L.) cv. Kodiak, as main plot and two cover crops planting time (June and July) as sub plot with four replication.

Table 1. Seeding rates of inter-seeded cover crops in 2019 at Ada and Prosper

Cover Crop	Cultivar	Seeding Rate (lbs/acre)
Austrian Pea		20
Camelina	Joelle	6
Mustard	Kodiak	10
Rye	ND Dylan	20

Individual treatment plots measured 11 feet wide and 30 feet long. Standard Roundup Ready sugarbeet cultivar was planted. The sugarbeet seeds were planted 4.75" apart. Recommended NPK fertilizers were applied prior to planting based on soil test. Sugarbeet planting was done at May 13th and May 16th for Ada and Prosper respectively. For Ada, first cover crop planting was done on 13th June and second on 24th June whereas for Prosper, first and second cover crop planting was done on 17th June and 2nd of July respectively. The cover crops were inter-seeded in between sugarbeet rows using a hoe. A 22 inches row spacing was used. Fungicide applications were done thrice, for the control of fungal diseases such as Cercospora in sugarbeet. Hand weeding was done to control other weeds in between the crops. The cover crop biomass was measured just before the harvest and 0-6" depth soil samples were analyzed for inorganic nitrogen concentration. Sugarbeet trials were harvested on September 16th and October 9th for Ada, MN and Prosper, ND respectively. The middle two rows of each plot were harvested and subsamples were analyzed to determine, crop yield, sugar percentage and recoverable sugar per acre. Yield determinations were made, and quality analysis was performed at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

The effect of cover crop inter-seeding on yield was analyzed using RCBD. The proc GLM procedure of the Statistical Analysis System (SAS Inc.) was used for analysis of variance of all data. Probabilities equal to or less than 0.05 were considered significant for main effects and interactions. The least significant difference (LSD) test was used to separate differences between treatment means if analysis of variance indicated the presence of such differences.

Table 2. Initial soil nutrient concentration and basic soil physical-chemical properties

Site	**Ada, MN**	**Prosper, ND**
Textural Class	Sandy Clay Loam	Silty Clay Loam
pH	7.6	6.7
NO_3-N 0-6" (lb ac^{-1})	14.4	16
Olsen P (ppm)	19.5	40
K (ppm)	171.6	280
OM (%)	3.07	3.3

RESULTS AND DISCUSSION

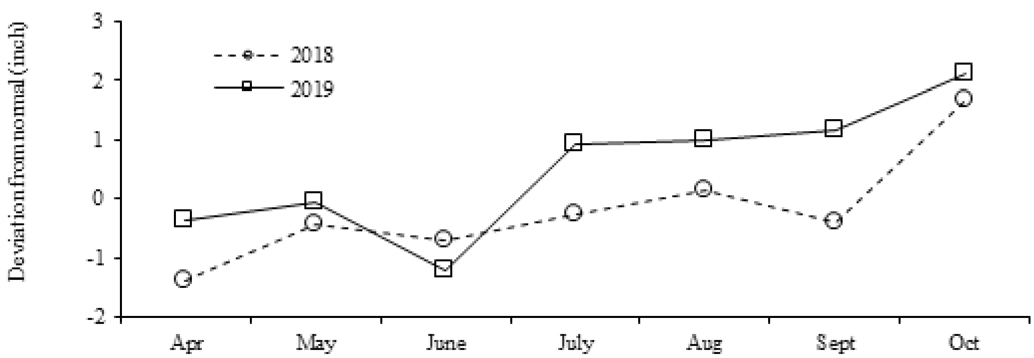


Figure 1: Deviation from normal precipitation (5 year average) during 2018 and 2019 at Ada, MN.

Precipitation was abnormally high in 2019. There was 25% and 59% more precipitation from May to October in 2019 than in 2018 at Ada and Prosper respectively. Rainfall in 2019 at Prosper was higher than at Ada.

Sugarbeet root yield: The cover crop treatment and its planting time significantly affected the sugarbeet root yield and sugar quality at Ada (Table 3).

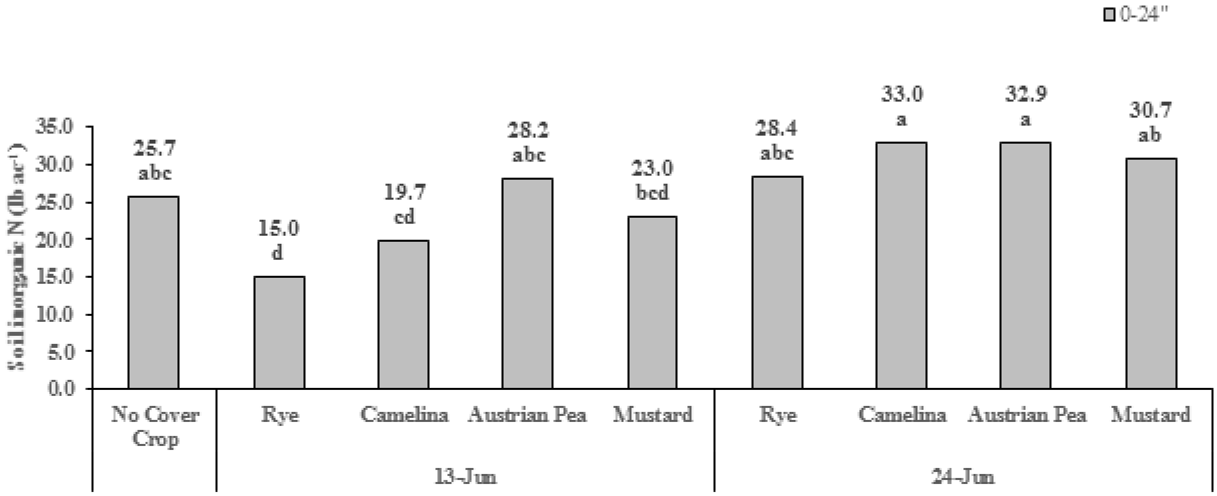
Table 3. Effect of different inter-seeded cover crops on sugarbeet root yield (tons acre^{-1}), sugar quality (%) and recoverable sugar/acre for Ada and Prosper during 2019 growing season.

Site	Planting Time	Treatment	Root Yield (ton acre^{-1})		Sugar %		RSA	
Ada, MN	13-Jun	No Cover Crop	30.87±4.04	AB	16.32±0.30	BCD	9219±1203	AB
		Rye	21.65±4.46	D	16.95±0.42	A	6716±1244	D
		Camelina	26.99±3.22	BC	16.82±0.46	AB	8315±774	BC
		Austrian pea	25.45±4.33	CD	16.31±0.25	BCD	7580±1201	CD
		Mustard	22.41±1.59	D	16.19±0.36	CD	6614±505	D
	24-Jun	Rye	30.77±0.84	AB	16.34±0.40	BCD	9186±84	AB
		Camelina	34.17±1.40	A	16.02±0.11	CD	9996±357	A
		Austrian pea	33.55±2.63	A	15.88±0.57	D	9714±368	A
		Mustard	32.08±1.53	A	16.54±0.30	ABC	9700±532	A
		$LSD_{0.05}$	4.33		0.54		1169	
Prosper, ND	17-Jun	No Cover Crop	35.79±3.51		14.87±0.63		9955±1024	
		Rye	34.30±5.40		14.84±0.24		9556±1543	
		Camelina	38.05±3.51		15.13±0.69		10772±745	
		Austrian pea	35.21±5.57		14.96±0.43		9803±1351	
		Mustard	33.61±4.24		14.83±0.78		9360±1102	
	2-Jul	Rye	37.42±4.52		14.41±0.84		10020±1215	
		Camelina	38.18±1.79		15.15±0.90		10560±963	
		Austrian pea	40.35±4.50		14.69±0.23		11071±1236	
		Mustard	38.30±2.99		14.65±0.58		10482±872	
		$LSD_{0.05}$	ns		ns		ns	

† Mean values for each soil followed by the standard deviation.
‡ Means within a column sharing a letter are not significantly (p=0.05) different from each other; ns= non-significant

Inter-seeding date and its interaction with cover crop species had significant effect on root yield. Sugarbeet root yield were significantly reduced if the planting date of inter-seeded cover crops were too early. Averaged across inter-seeding time at Ada site, root yield for 13-June inter-seeded cover crop treatments i.e. 24.13 tons acre^{-1}, were lower than that of control (30 tons acre^{-1}) and 24-June inter-seeding (32.65 tons acre^{-1}). Here, the rapid establishment of early inter-seeded cover crops caused severe competition with sugarbeet resulting in yield reduction for 1st planting. However, root yield for 2nd inter-seeding time have some potential advantages. Here, we can observe, late inter-seeded cover crop plot had consistently higher yield than any of the plots (Table 3). Among the treatments, 24-June inter-seeded camelina produced highest root yield of 34 tons acre^{-1} but was not significantly different from control.

For Prosper ND, root yield from inter-seeded plots were not significantly different from those of control in 2019. This shows no effect on root yield of sugarbeet due to inter-seeding of rye, camelina, pea and mustard at Prosper. *Sugar Content:* In 2019, at Ada MN, there were no differences among treatments and control for sugar content, expect for early inter-seeded rye, where rye had significantly higher sugar concentration than of control with no cover. For Prosper, there were no differences among the treatments. Besides, due to the extreme wet growing conditions the cover crops at Prosper either was choked out due to canopy closure or drowned out due to excessive rainfall.



Recoverable sugar per acre: Recoverable sugar per acre is affected mainly by root yield and sugar quality. The cover crop treatment and its inter-seeding time did not affect recoverable sugar per acre at Prosper. However, at Ada, for 2nd inter-seeding the recoverable sugar per acre increased over 1st inter-seeding and control. Early competition between cover crop and beet did decrease the amount of recoverable sugar per acre for 1st inter-seeding time, mainly due to reduced root yield in the cover crop treatments.

Figure 1: Effect of cover crop interseeding on residual soil inorganic N (lb ac^{-1}) after harvest at 0-24" depth during 2019 at Ada.

CONCLUSION

Under the conditions of this experiment, root yield and sugar quality were affected by time of cover crop seeding and species type at Ada, MN. Cover crop inter-seeding at least 40-45 days after beet emergence did not affect the sugarbeet root yield. The reduction in root yield for early inter-seeding was probably the result of competition between planted cover crops and beet. However, more research is needed to identify what environmental conditions and practices would reduce the risk of yield loss following inter-seeding.

ACKNOWLEDGEMENT

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SUGARBEET PHYSIOLOGY/STORAGE/PRODUCTION PRACTICES/ECONOMICS

NOTES

LIQUID SEPARATED DAIRY MANURE AS A NUTRIENT SOURCE IN A SUGARBEET ROTATION

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JUSTIFICATION FOR RESEARCH:

Using manure as a nutrient source can be more complicated than using commercial fertilizers since the nitrogen (N) and phosphorus (P) content can vary depending on species, storage and treatment methods, and application techniques. Farmers, particularly those that grow sugarbeets, are also concerned about when the nutrients are released in the growing season which changes depending on soil types and weather. Despite concerns, there are other benefits of manure beyond being a source of N and P, including improving soil health and providing micronutrients. Plus, the up and down price swings of the commercial fertilizer market make manure more attractive, especially if a farmer has a consistent supply which can offset fertilizer costs.

As large dairies are moving into western Minnesota, a consistent supply of manure is no longer a problem. However, these dairies are using a new technology to separate solids from liquids in the manure, and the impact on nutrient availability in this region's climate and soil types is unknown. Understanding this is particularly important for sugarbeet growers due to the effect that late season N availability in the soil has on the sugar content of their crop. Where in the rotation should this manure be applied to maximize the beneficial properties while minimizing risk of low sugar content due to excess nitrogen? Our goal is to answer this question so that farmers are able to make better decisions about using dairy liquid separated manure in their rotation to reduce fertilizer costs.

SUMMARY OF LITERATURE REVIEW:

Little recent information is available on the effect of manure on sugarbeet root yield and quality. Halvorson and Hartman (1974) reported that sucrose concentration and recoverable sugar per acre were reduced with the addition of beef manure while root yield was increased. Schmitt et al. (1996) reported that swine manure mineralization occurs several years after application in a legume-corn rotation. Swine manure was found to be 80 to 90% available in the first year of application for corn production.
Since that time, the most activity for manure applications in sugarbeet production systems has been conducted in the Southern Minnesota Beet Sugar Cooperative (SMBSC) growing area although it is expanding to other sugarbeet growing regions as well. Three major research projects have been conducted in the SMBSC growing area since 1999 and are summarized below.

<u>Project 1</u>. Lamb et. al 2002, Manure application on sugarbeet 1999-2001: The objectives of the first research project were to: 1) measure turkey and swine manure application effects on sugarbeet root yield and quality compared to fertilizer N applications; 2) determine the effect of manure mineralization differences on sugarbeet root yield and quality; and 3) develop management strategies for manure application in a sugarbeet rotation. The results from the three sites of this study indicated that the use of manure on a field with no prior manure application may not be as detrimental to sugarbeet quality as originally thought. However, the effect of manure application to sugarbeet root yield and quality on fields with a history of manure applications was not answered with this study. If manure was applied at reasonable rates equivalent to the N fertilizer recommendation, it did not negatively affect sugarbeet recoverable sucrose per acre on fields with no manure application history. Excessive application rates of manure will reduce quality.

Soil nitrate-N values during the growing season indicate that while the sugarbeet plant is actively growing, it will utilize most of the nitrate-N mineralized into the soil from manure. This utilization is greater than corn or soybean. A soil test for nitrate-N taken in the later stages of corn or soybean growth will reflect excess nitrate-N mineralized from manure. A nitrate-N soil test taken at later stages of the growing season will not reflect excess soil nitrate-N during sugarbeet production.
Results from 1999 indicated that sugarbeet top N concentration and N uptake at harvest reflect the N additions from both fertilizer and manure. This did not occur in the 2000 growing season. A long period of drought conditions during August and September in which the sugarbeet plant was under moisture stress affected the plant uptake of soil nitrate-N.

Project 2. Lamb et. al 2013, Turkey litter use in a sugarbeet crop rotation 2007-2012: Turkey manure has a considerable amount of litter from bedding in it, thus slowing initial release of poultry manure-N. The implication of the manure-N release is critical, especially to sugarbeet growers. This research project was designed to: 1) determine when in a three-year rotation should turkey litter be applied and 2) determine nitrogen fertilizer equivalent of turkey litter applied two and three years in advance of sugarbeet production in the rotation.
With three sites worth of information, it was concluded that if a grower must apply turkey litter in the sugarbeet production system, it should be applied in the fall before sugarbeets. This conclusion is not what the current recommendation is. Caution about the use of any kind of manure in rotation should be used. In this study, the manure application rates were not excessive. Excessive applications could cause problems with quality. Applications made more than once during a three-year rotation should be avoided for the same reason. Too much of a good thing (turkey litter) can cause problems with management of the residual soil nitrates in the soil system.

Project 3: Lamb et. al 2016, Liquid swine manure in a sugarbeet production rotation 2010-2015: This research project was designed to: 1) determine when in a three-year rotation should swine manure be applied; 2) determine nitrogen fertilizer equivalent of swine manure applied one, two, and three years in advance of sugarbeet production; and 3) determine the effect of over-fertilization with N on the quality, root yield, and summer petiole nitrate-N. The results from this study can be summarized in the following two areas:

I. The effect of timing of manure application in the soybean, corn, sugarbeet rotation.
1. Manure application significantly affected 2 of the 3 sites.
2. At the 2 sites, manure application increased root yield and extractable sucrose per acre. The closer to sugarbeet production the application is made, the greater the root yield and extractable sucrose per acre response.
3. The application of swine manure in the fall before sugarbeet production significantly decreased sugarbeet sucrose concentration and extractable sucrose per ton. Depending on the quality payment system, this reduction can be economically significant.

II. The effect of manure application timing in the rotation and the application of N fertilizer before sugarbeet production.
1. No interaction occurred between N fertilizer application and manure management for any yield or quality variable measured at 2 of the 3 sites.
2. N fertilizer rate increased root yield and extractable sucrose per acre at 2 of the 3 sites.
3. Manure management affected root yield and extractable sucrose per acre at 1 site. The closer you apply manure to sugarbeet production, the greater the yield. There was no effect at 2 sites.
4. N fertilizer application decreased extractable sucrose per ton at 2 of the 3 sites. This could affect the payment.

For both turkey and swine manure, application rates near the recommended amount of N for sugarbeet production resulted in an increase in root yield and extractable sucrose per acre. This application also reduced quality parameters such as sucrose concentration and extractable sucrose per ton. The application should be made the fall before sugarbeet production in the crop rotation. Unless the sugar payment is heavily quality-based, then increases in root yield and extractable sucrose per acre will make up for the decreases in quality. More information is needed regarding dairy manure applications, particularly liquid-separated dairy manure, as this is becoming more readily available in some sugarbeet production areas.

OBJECTIVES

The objective of this study is to evaluate the timing and rate of dairy liquid separated manure in a sugarbeet-soybean-corn rotation on crop yields and sugarbeet quality.

MATERIALS AND METHODS

This is a 3-year field study at two locations - near Willmar, MN and Wahpeton, ND - in collaboration with the Southern Minnesota Beet Sugar Cooperative and Minn-Dak Farmers Cooperative. The goal was to see what part of a three-year rotation is best for dairy liquid-separated manure application. This study utilized a split plot experimental design with four replications. The main plots represent a crop rotation common to each sugarbeet growing region. Each treatment in the main plots started with a different crop in the rotation in Year 1 (see table 1). This allowed each crop to be planted in each year. Manure was only applied in the subplots during the first year of this study as this allowed for observation of where manure application had the greatest benefit within the crop rotation (before corn, sugarbeet, or soybean). After the first year, we continued to monitor the impact of that one application throughout the rest of the rotation. All crops were planted on 22-inch rows.

Table 1. Main plot treatments.

Treatment	Year 1	Year 2	Year 3
1	Corn	Sugarbeet	Soybean
2	Soybean	Corn	Sugarbeet
3	Sugarbeet	Soybean	Corn

Various manure application rates acted as treatments for the subplots (see table 2). The treatments were comprised of a high application rate (about 14,400 gallons per acre), a low application rate (about 9,500 gallons per acre), or no manure applied. The ‘high’ and ‘low’ rates were chosen based upon the rates typically offered by the large dairies specific to each region. Where manure was not applied in the first year, the crops were fertilized with commercial nutrients according to the state University guidelines. In years 2 and 3, state University fertility guidelines were utilized to apply commercial fertilizers to all plots, taking into account any residual fertility credits from the initial manure application.

Table 2. Sub-plot treatments.

Treatment	Year 1	Year 2	Year 3
a	Fertilizers	Fertilizers	Fertilizers
b	Manure low rate	Fertilizers w/ second year manure N credit	Fertilizers w/ third year manure N credit
c	Manure high rate	Fertilizers w/ second year manure N credit	Fertilizers w/third year manure N credit

Each experimental crop was taken to harvest and evaluated for yield, quality, and any other appropriate crop-specific quality parameters. Plot-specific 0-6 inch soil samples were collected prior to planting in each experimental year and subjected to routine soil analyses. Nitrate analysis on 0-2 foot and 0-4 foot soil samples was conducted on plots that were planted to corn and sugarbeets, respectively. Soil samples (1-ft depth) were collected 2-3 times throughout each growing season to monitor potential changes in the levels of both nitrate and ammonium.

PRELIMINARY RESULTS

This experiment was begun in the fall of 2019 at a farm site near Willmar, MN. Manure was surface applied and incorporated within 24 hours of application. Fertilizers will be applied as appropriate in the spring prior to planting crops. Initial soil samples and manure samples were collected and are in the process of being analyzed. There is no other data to present at this time.

The site near Wahpedon, ND was unfortunately not started at this time due to the fields being flooded and it would have been inappropriate to apply manure in these conditions. We will try to start this experiment in that location in fall 2020.

References

Halvorson, A.D., and G.P. Hartman. 1974. Longtime influence of organic and inorganic nitrogen sources and rates on sugarbeet yield and quality. In 1974 Sugarbeet Research and Extension Reports p. 77-79.

Lamb, J.A., M.W. Bredehoeft, and C. Dunsmore. 2013. Turkey litter effects on sugar beet production. In 2012 Sugarbeet Res. And Ext. Rpts, https://www.sbreb.org/research/.

Lamb, J.A., M.W. Bredehoeft, J. Rademacher, N. VanOs, C. Dunsmore, and M. Bloomquist. 2016. Swine manure application management in a sugar beet rotation. In 2015 Sugarbeet Res. And Ext. Rpts. https://www.sbreb.org/research/

Lamb, J.A., M.A. Schmitt, M.W. Bredehoeft, and S.R. Roehl. 2002. Management of turkey and swine manure derived nitrogen in a sugar beet cropping system. In 2001 Sugarbeet Res. and Ext. Rpts. 32:125-134.

Schmitt, M.A., C.C. Sheaffer, and G.W. Randall. 1996. Preplant manure on alfalfa: Residual effects on corn yield and soil nitrate. J. Prod. Agric. 9:395-398.

DETERMINING NUTRIENT RELEASE CHARACTERISTICS OF VARIOUS MANURES

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JUSTIFICATION FOR RESEARCH

Using manure as a nutrient source can be more complicated than using commercial fertilizers since the nitrogen (N) and phosphorus (P) content can vary depending on species, storage and treatment methods, and application techniques. Farmers, particularly those that grow sugarbeets, are also concerned about when the nutrients are released in the growing season which changes depending on soil types and weather. Despite concerns, there are other benefits of manure beyond being a source of N and P, including improving soil health and providing micronutrients. Plus, the up and down price swings of the commercial fertilizer market make manure more attractive, especially if a farmer has a consistent supply which can offset fertilizer costs.

To help farmers understand nutrient management with manure, the University of Minnesota developed recommendations to help determine N and P credits for a variety of manures. These recommendations were developed several decades ago, however, and since that time the diets of animals, storage of manures, and manure application equipment have changed. As one example, the recommendations to determine N availability treat all dairy liquid manure the same. However, some dairies have implemented technology to separate the solids from the liquids, thus changing the nutrient dynamics of the manure. Will liquid separated dairy manure have the same N availability as unseparated liquid dairy? For both N and P, are there differences in mineralization across soil types? These questions are particularly important for sugarbeet growers due to the effect late season N availability in the soil has on the sugar content of their crop. Our goal is to better understand N and P release from manure so that farmers are able to make better decisions about when to apply manure in their rotation to maximize benefits while reducing fertilizer costs.

SUMMARY OF LITERATURE REVIEW

Understanding N availability in manure is complicated. The amount that is available will depend on the animal species that made the manure, what kind of bedding (if any) was used, how the manure was treated and/or stored, and how the manure was applied. The University of Minnesota has recommendations for what to expect for N availability (Hernandez and Schmitt 2012), but may need updated since there are new manure handling technologies and feeding and bedding strategies being used today. For example, Russelle et al. (2009) found that nutrient release estimates for stratified bedded pack dairy manure were not consistent with solid dairy manure guidelines in Minnesota. With new state regulations pending regarding how much fertilizer N is applied to fields, farmers that also use manure will need to take great care in determining how much N is supplied from the manure before determining how much fertilizer they can apply.

Understanding P availability in manure is also necessary, and luckily is not quite as complicated as it is with N, although there are still uncertainties. We assume approximately 80% of the total manure P is available the first year, but even this can vary depending on weather conditions. Recent studies have shown, however, that P availability may also depend on soil texture (Pagliari and Laboski 2014). In a recent study done at the University of Wisconsin, Pagliari and Laboski (2013; 2014) found that from 40% to 100% of P from manure became plant available within 50 days and the difference was primarily due to manure chemistry and soil texture.

OBJECTIVES

The objective of this study is to evaluate N and P release from a variety of manures and soil types to give farmers a better understanding of how manure will behave.

MATERIALS AND METHODS

Laboratory incubations were used to assess N and P release characteristics from a variety of manures in several different soil types. The incubation studies were a complete factorial with 4 replications and with manure type, soil type, and temperature as the main factors. This means all possible soil and manure combinations were tested at all chosen temperatures. We also included a control treatment that did not include any manure application to see how much nitrogen and phosphorus mineralized from the soils themselves. We tested 8 manures, including: dairy liquid (separated and raw [non-separated]), swine liquid (from a finishing house and a sow barn), beef manure (solid bedded pack and liquid from a deep pit), and poultry (turkey litter and chicken layer manure). Manure analyses to determine nutrient content were conducted on all samples prior to incubations. Soils for the incubations included a coarse textured soil from the Sand Plain Research Center at Becker, MN; a medium textured soil from a research field near Rochester, MN; and a fine textured soil from the West Central Research and Outreach Center in Morris, MN. Soils were collected from the top six inches of soil at each location in bulk and then air dried and analyzed for nutrient and organic matter content.

To determine how much plant available N and P was released over time, we made subsamples for each manure by soil type by temperature treatment, and then collected one each at predetermined sampling intervals. Each subsample consisted of 200 grams of soil placed into ball jars and brought to about 60% moisture. These were allowed to incubate for a week prior to manure being added. After one week, manure was mixed into the jars to mimic a given amount of nutrient (e.g. 180 lbs of N per acre). We used the University of Minnesota guidelines and manure analysis results to calculate the appropriate application rate for each manure type. Moisture in the samples was kept at 60% of field capacity and was maintained by weighing every 4-6 days and adding deionized water as needed to replace the weight lost. During the incubation study, the temperature inside the incubator was kept at either 25ºC (77ºF), 15ºC (60ºF), or 5ºC (40ºF). We collected subsamples at 0, 7, 14, 28, and 56 days after the experiment had begun. Subsamples were destructively analyzed for potassium chloride extractable ammonium and nitrate and Bray-1 or Olsen extractable phosphate.

PRELIMINARY RESULTS

At the time of writing, the experiment has been completed at all three temperatures and we have collected 3,672 samples. Sample analysis continues to be underway and we expect to have results by the next reporting period. Since the data collection is not yet complete, statistical analyses have not been conducted at this time. The results of the initial soil and manure tests can be found in Tables 1 and 2, respectively. This will give an idea of the starting conditions of the soils and manures.

Soil phosphorus (Bray-P) testing at 5°C (40°F) showed interesting results (Figure 1). In the control soils that did not have manure applied, Bray-P test levels were similar at the beginning and end of the incubation, although there were some fluctuations across time. All values were below 20 ppm of Bray-P. Within a few days of application, Bray-P levels were more variable across soil types and application rates, likely due to differences in how long it took for the phosphorus to equilibrate across different pools of P. However, there tended to be higher Bray-P levels in the clay loam soil than the silt loam soil at the end of the incubation (56 days). Bray-P tests in the sand loam tended to be between the silt and clay loam or similar to the clay loam. Overall, Bray-P test levels were below 30 ppm for most manures at the end of the incubation, with the exception of some of the turkey litter, swine sow manure, and bedded beef pack manure samples. We expect to see more variability in the incubations at warmer temperatures. More tests are needed and will be completed later in 2020.

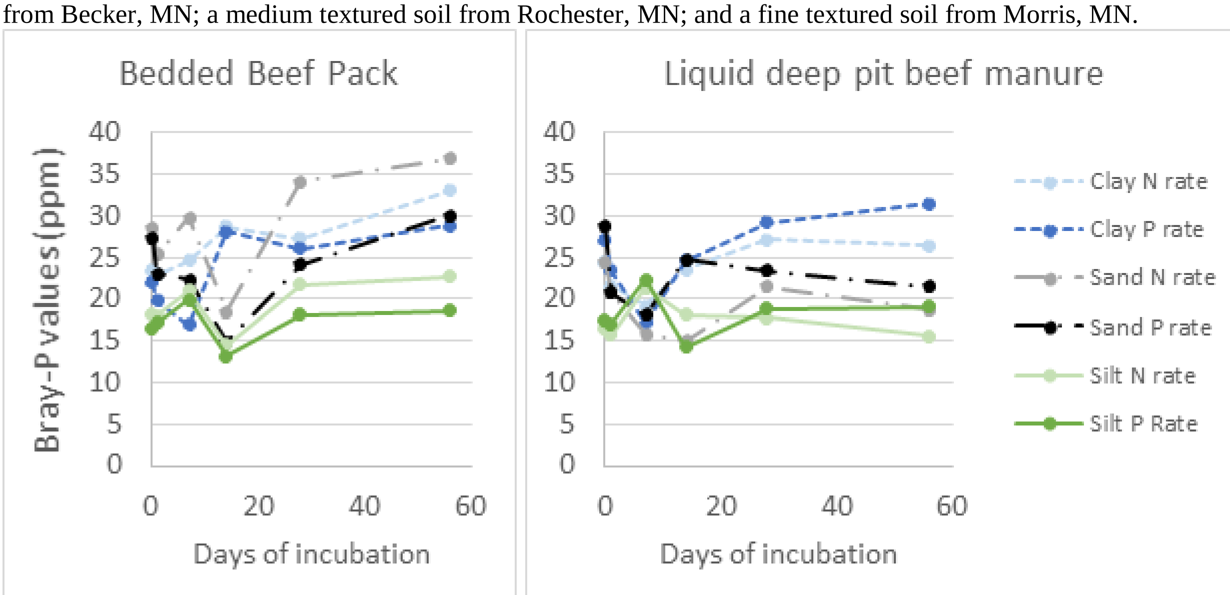
Table 1. Initial characteristics of three soil types used in this study: coarse textured soil from Becker, MN; medium textured soil from Rochester, MN; and a fine-textured soil from Morris, MN.

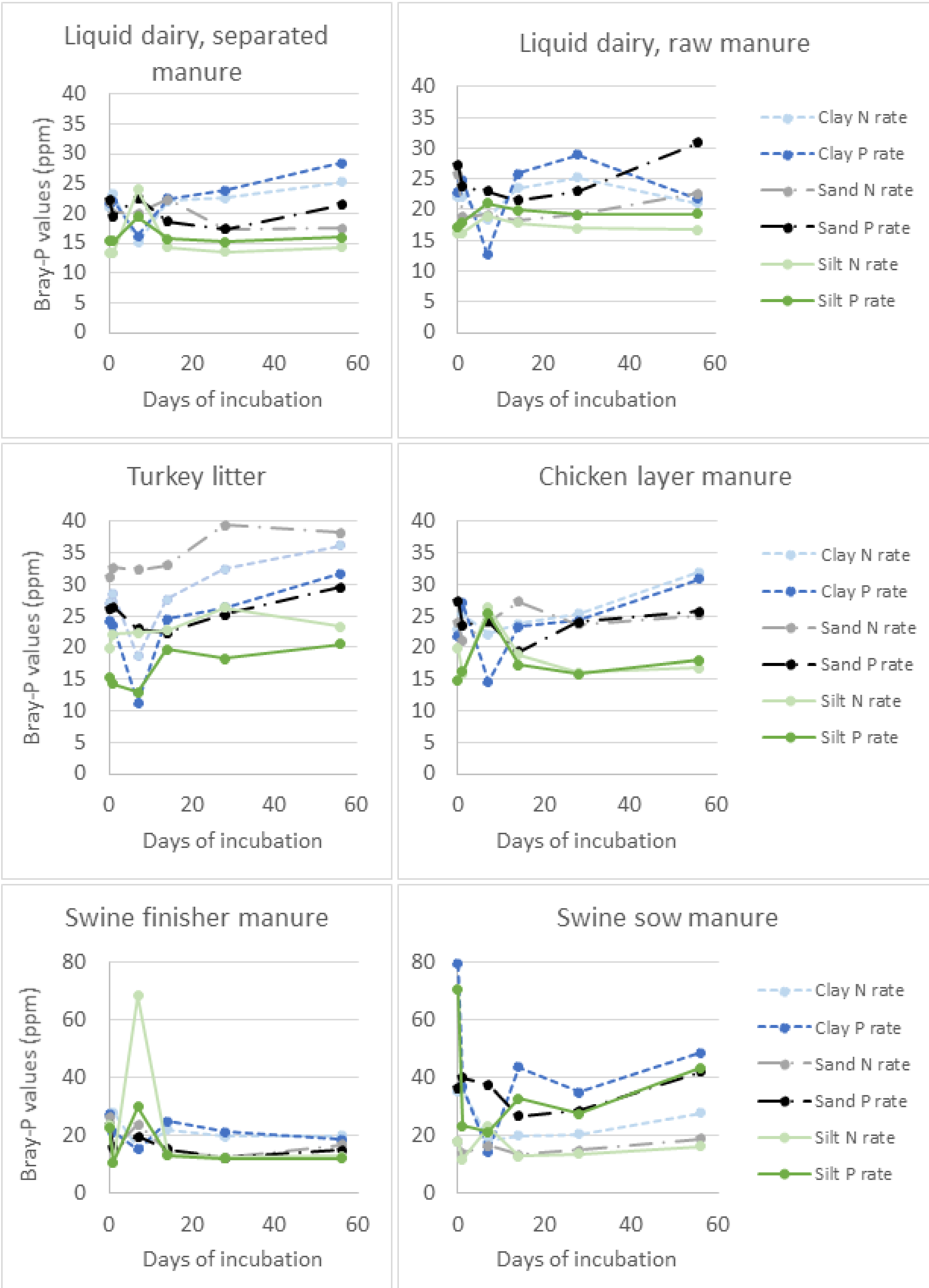
Soil Characteristics	Soil Textural Class		
	Coarse	Medium	Fine
Organic matter (%)	1.1	1.0	3.3
pH	5.1	5.2	7.9
Phosphorus - Olsen (ppm)	11	8	7
Potassium (ppm)	95	101	140
Magnesium (ppm)	42	49	570
Calcium (ppm)	274	310	3482
Ammonium (ppm)	3.4	2.8	8.6
Nitrate (lb/acre)	3.0	2.5	8.5

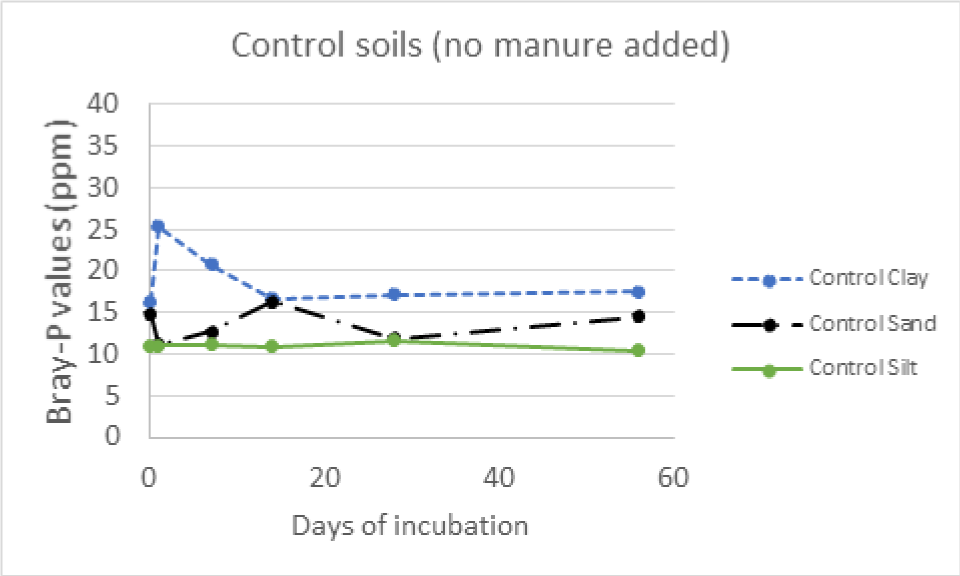
Table 2. Initial characteristics of eight manure types used in this study. The units of nutrients will be in pounds per ton for solid manure and in pounds per 1000 gallons for liquid manure.

Species Type	**Manure Type**	**Moisture**	**Total N**	**Ammonium-N**	**Total P (as P_2O_5)**	**Total K (as K_2O)**	**C:N Ratio**
		(%)	(lbs per unit)	(lbs per unit)	(lbs per unit)	(lbs per unit)	
Beef	Bedded Pack, Solid	60.5	13.43	2.37	9.59	18.01	22:1
	Deep Pit, Liquid	86.6	56.72	36.7	23.43	30.83	9:1
Dairy	Separated, Liquid	93.2	32.7	15.8	13.31	29.26	7:1
	Raw, Liquid	88.9	33.17	15.66	13.08	31.29	13:1
Swine	Finisher, Liquid	86.8	59.16	41.63	37.63	27.35	9:1
	Sow, Liquid	99.3	16.5	15.69	1.38	11.34	1:1
Poultry	Chicken Layer, Solid	48.6	55.51	14.39	35.78	25.91	7:1
	Turkey Litter, Solid	53.0	28.2	13.16	26.69	28.65	12:1

Figure 1. Soil test phosphorus levels (Bray-P) in soil mixed with various manure types in a coarse textured soil from Becker, MN; a medium textured soil from Rochester, MN; and a fine textured soil from Morris, MN.




Liquid dairy, separated manure
Liquid dairy, raw manure
Turkey litter
Chicken layer manure
Swine finisher manure
Swine sow manure
Bray-P values (ppm)
Days of incubation
Clay N rate
Clay P rate
Sand N rate
Sand P rate
Silt N rate
Silt P rate



References

Hernandez JA, Schmitt MA. 2012. Manure management in Minnesota. Saint Paul (MN): University of Minnesota Extension [accessed 24 Nov 2017].

Pagliari PH, Laboski CAM. 2013. Dairy manure treatment effects on manure phosphorus fractionation and changes in soil test phosphorus. Bio and Fert of Soils 49(8): 987-999.

Pagliari PH, Laboski CAM. 2014. Effects of manure inorganic and enzymatically hydrolyzable phosphorus on soil test phosphorus. Soil Soc. of Am. J. 78(4): 1301-1309.

Russelle MP, Blanchet KM, Randall GW, Everett LA. 2009. Characteristics and nitrogen value of stratified bedded pack dairy manure. Crop Management 8(1). https://dl.sciencesocieties.org/ publications/cm/abstracts/8/1/2009-0717-01-RS.

VARIATION IN PLANT TISSUE CONCENTRATION AMONG SUGARBEET VARIETIES

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JUSTIFICATION

Plant tissue analysis has increasingly been used for crops as a tool to fine tune nutrient management. Plant analysis was developed as a diagnostic tool and is generally not been used to determine nutrients to apply. For sulfur, analysis of sulfur in plant tissue is commonly determined using inductively coupled plasma emission spectroscopy (ICP) even though older data that is typically used to develop sufficiency ranges may have been determined by dry combustion. Recent work in Minnesota on corn and soybean has found differences in the assessment of sulfur concentration by ICP versus combustion. Comparison of methods of analysis for sulfur for additional crops such as sugarbeet would help to determine the accuracy of ICP and where additional research in correlation of plant tissue tests to crop yield should be conducted. If differences in the methods can be documented, it would indicate that sugarbeet growers should exercise extreme caution when interpreting plant tissue results for sulfur.
Plant tissue analysis has resulted in more recent questions on boron application than other micro-nutrients. Reports that list boron as being low typically suggest a foliar application of boron containing fertilizer sources. However, there is no documented evidence that tissue sufficiency ranges currently used are accurate and that when a low tissue boron concentration is reported that application will increase crop yield. Comparisons of yield response to tissue concentration are needed to provide evidence that a sufficiency range actually has meaning when deciding if fertilizer should be applied.
Recent surveys of corn, soybean, and hard red spring wheat plant tissue has shown significant variation in nutrient concentration when multiple hybrids/varieties are sampled in the same field at the same time. If taken at face value, tissue nutrient concentration should be reflective of soil nutrient status. Past research on corn, soybean, and wheat showed a significant portion of the variation in nutrient concentration was due to growth stage differences among hybrids/varieties at sampling. What needs to be addressed for sugarbeet if the degree of variation in tissue nutrient concentration in petioles and leaf blades for varieties grown at multiple locations and years and whether plant tissue analysis can be related to root or sugar yield. If there is significant variation in concentration that is reflective of genetics and not of yield potential, there should be a significant degree of caution when interpreting tissue results without further documentation of deficiencies with additional analysis such as soil tests.

SUMMARY OF LITERATURE

Plant tissue analysis is being utilized more as a tool to determine whether nutrients should be applied in-season to maximize yield of crops. Plant analysis is only suggested for use for diagnosing problems that may occur in field (Kaiser et al., 2013). Fertilizer decisions should be made using soil samples which have been correlated and calibrated to crop response. Never the less, samples are being taken in fields and are being used to sell products which are likely not needed. Databases for "sufficient" levels for nutrients have been developed for use in diagnosing problem areas within fields (Bryson et al., 2014). It is not known whether these sufficiency values were generated using crop response data that documents that yield will be reduced when tissue concentrations are below the stated sufficiency level. It is more likely that the sufficiency values used currently for nutrients such as sulfur or boron are developed based on tissue concentration averages for plots where either nutrient was added but no yield response was achieved. Since both boron and sulfur can be taken up by plants in excess quantities, utilizing averages values of fertilized plots can result in the development of sufficiency ranges that are higher than what would actually be required for maximum crop yield. Most of the research previously cited has shown the effects of boron or sulfur on petiole or leaf blade boron or sulfur concentration the works have not taken the next step in correlating it to crop yield.

Understanding potential sources of variation is important when interpreting plant tissue analysis results. One major source of variation can be differences in uptake patterns among hybrids or varieties. In Minnesota, unpublished survey data for corn and soybean and published data for hard red spring wheat (Kaiser et al., 2014b) found significant variation among hybrids/varieties for a majority of the nutrients analyzed. For the wheat trials, the majority of the variation in nutrient concentration across locations could be attributed to when the samples were collected and the stage of development of the plant at the time of sampling. For all crops the variation in yield could not be explained by one or more nutrients measured in the plant tissue. For sulfur, data collected from multiple crops has noted differences in the amount of sulfur reported in plant tissue based on how the samples are analyzed in the lab (Sterrett et al., 1987). These sources of variation indicate that varieties may have their own sufficiency range for nutrients and that ranges need to be developed based on specific laboratory methods used to determine the concentration of nutrients in plant tissue.

OBJECTIVES

1. Compare nutrient concentration in petioles and leaf blades among varieties at three sampling times.
2. Determine if tissue nutrient concentration is predictive of root and sugar yield when sampling adequately fertilized fields.

MATERIALS AND METHODS

Six sugarbeet varieties (listed below) were planted at four locations [three locations were sampled in 2019 (Table 1)] and tissue analysis samples was collected at three sampling times over the growing season. Varieties were planted in four replications at each site. Sampling times were early- to mid-June, early July, and late July to early August. The newest developed leaf was sampled. The petiole and leaf blade will be sampled at once then separated for individual analysis. All samples were dried, ground, and analyzed for nitrate N and Cl via extraction with 5% acetic acid, total N by combustion, and P, K, Ca, Mg, S, B, Cu, Fe, Mn, and Zn by ICP. A single composite soil sample consisting of six to eight cores was taken from the 0-6 and 6-24 inch depths from each site at each plant sampling date. Soil samples were analyzed using recommended procedures of N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn, and Cl and for pH (1:1 soil:water), soil organic matter (loss on ignition), and cation exchange capacity [CEC (ammonium saturation and displacement)]. Plant tissue nutrient concentration was correlated with yield and quality to determine what factors may be important for the prediction of root and sugar yield. All data was subject to an analysis of variance procedure assuming fixed effects of location, sampling time, and variety and random blocking effects.
Varieties used in the sampling trial:

1. Crystal RR018 – Check variety: Good disease tolerance, average yield but below average sugar.
2. Maribo 109 – Check variety: Good disease tolerance with average sugar content. Below average tons. Tends to have a smaller leaf canopy than other varieties.
3. Beta 92RR30 –Average tons and average sugar.
4. Beta 9475 –Good Cercospora leaf spot resistance, high yield, average sugar
5. Crystal M579 –High sugar content.
6. Crystal M509 – Good cercospora resistance, low sugar content and high yield.

RESULTS

Sample timings were targeted to occur within three week intervals near the 50-80 day suggested for sugarbeet sampling. Actual sampling dates averaged 45, 65, and 88 days after planting which was ideal for the trial to study early, suggested, and late sampling timings. Soil types, chemical properties, and cation exchange capacity was relatively similar among soils at the eight locations. Results for chemical soil tests for samples collected from each location at the time samples were collected are summarized in Table 2a, 2b, and 2c.
Root yield, sugar content per ton, and sugar content produced per acre varied among the six varieties across all four 2017 (Table 3a), 2018 (Table 3b), and 2019 (Table 3c) locations. The four site average for each of the variables is given in Tables 3a, 3b, and 3c. However, analysis indicated a significant interaction between site and variety for each year providing evidence of variation in the ranking of varieties among the sites. Overall, root yield, sugar content, and sugar production followed anticipated patterns based on past varietal response data, but variety rankings did slightly vary by year. Some variation in varietal ranking may be due to differences in yield potential as a result of cercospora which had a greater incidence across locations in 2018 (not shown) Root yield and quality did vary allow for correlation between yield and quality and plant tissue concentration.
Results for the analysis of variance for leaf blade tissue concentration are summarized across locations and years in Table 4. The effect of time and variety was significant for most nutrient concentrations. Exceptions were when differences were not found among sampling times for sulfur and boron and among varieties for total nitrogen, sulfur, and boron. Nutrient concentrations differed among locations except for phosphorus, potassium, magnesium, sulfur, and boron which did not differ based on location. The location by time interaction was significant for nearly all

nutrients except for total nitrogen, phosphorus, sulfur, and boron. The time by variety and location by variety interactions along with the three-way time by location by variety interaction was significant at roughly half the locations. For the interest of time, the discussions will not be discussed extensively in this report. Similar results were found for petiole concentration (Table 5).

Differences in leaf blade nutrient concentration among varieties, when averaged across time and location, are summarized in Table 6. While significant, the relative differences in plant nutrient concentrations among the varieties were relatively small. The ranking among varieties (maximum to minimum concentrations) were not consistent indicating that varieties with greater nutrient concentration of a single nutrient were not greater for all nutrients. This indicates that plant nutrient uptake is not relatively greater for one variety versus another for all nutrients. Table 6 also lists the anticipated sufficiency range according to Bryson et al., 2014. The average for boron tissue concentration was the only instance where a concentration average was close to the low end of the sufficiency range. However, the boron concentration in the leaf blade tissue did not necessarily indicate that boron was limiting yield. Results for leaf blade nitrate nitrogen and chloride are listed in Table 6 but there is no given sufficiency ranges for these nutrients.

Effects on all nutrient concentrations were similar for petioles (Table 7) as with leaf blades. However, the concentration of nutrients tended to be less in the petiole than in the leaf blade tissue. The major exceptions were potassium and chloride where the concentration was greater in the petiole than in the leaf blade. There is no identified sufficiency range for petiole tissue to compare results with established ranges.

The effect of time on macro- and micronutrient concentrations is summarized in Figures 1 and 2, respectively. Most nutrients decreased in concentration in both the leaf blade and petiole samples over time starting at time one through time three. There were exceptions where some nutrients did not change over time or showed a temporary decrease from T1 to T2 but then increased from T2 to T3. Iron did exhibit a decrease over time, but this decrease was likely due to less soil contamination on leaves later in the growing season. As more leaves developed it was less likely that rain drops would reach the soil surface resulting in splashing of soil particles onto plant tissue. Due to contamination, tissue iron concentration should not be used as a predictor of yield and quality parameters. There was a large increase in copper from T2 to T3. The concentration of copper spiked in the leaf tissue at sampling time three as a result of copper being applied to treat cercospora. Tissue sulfur concentration generally increased in the leaf blade while it decreased in the petiole.

Table 8 summarizes the 25 to 75% confidence interval for each nutrient by sampling time for leaf blade tissue and petiole concentrations are summarized in Table 9. The 25-75% confidence interval is typically used to identify where the “true mean” lies. Population statistics are sometimes used in lieu of sufficiency data to represent “normal” values for tissue concentration. In this case the confidence interval ranges were much smaller than the ranges used for sufficiency ranges, and in the case of the early sampling time 1, the 25% value was generally higher than the low end of the reported sufficiency ranges for leaf blade tissue. The main issue to note is the general decrease in the sufficiency range over time indicating that a singular set of recommendations from 50-80 days after planting may not be relevant as value may get lower over time increasing the likelihood of insufficient nutrient levels being reported to growers. Others may report sufficiency ranges as plus or minus two standard deviations from the mean. In any event, without supporting data on yield or quality changes due to differences in nutrient concentrations one cannot be certain whether a reported low value has meaning and needs to be corrected.

Simple correlation between individual nutrient concentration in the leaf blade and petiole at each sampling time and sugarbeet root yield is summarized in Table 10. There were significant positive and negative correlations among most of the nutrients studied. There was no instance where a single nutrient always showed a positive correlation with root yield. For example, total nitrogen content in the leaf blade and petiole were positively correlated with root yield at T1 but was not correlated by T3. The greatest correlation was between leaf petiole total N at T1 and root yield (r=0.73) which was similar to the correlation between root yield and petiole total N concentration. The next strongest correlation was a negative relationship between leaf and petiole calcium concentration and root yield at T2 and leaf blade total nitrogen concentration at T1.

Table 11 summarizes the correlation between plant tissue and sucrose content and Table 12 summarizes correlation with sugar production per acre. Similar to root yield, there were no instances where sugar content or yield showed a consistent correlation with multiple nutrient. It would be expected that if a nutrient is limiting or if yield or quality is a function of nutrient concentration then there should be consistent correlation over time between these factors and the concentration of nutrient in the plant tissue. Nutrient concentration in plant tissue does not necessarily account for variations in plant growth and differences in nutrient remobilization among varieties. The data overall indicates

that some caution should be exercised when interpreting plant tissue results as a correlation between yield and quality and a concentration of a specific nutrient at a single point during the growing season does not prove that uptake of any nutrient is driving final yield or sugar production.
What has been interesting is the change in correlation values as more data has been added to the study. Previous correlations are not given in this report but are listed in older reports. Over time there have been changes in what nutrients are more, and which are less correlated to the root yield and quality parameters. The change over time indicates that some caution should be exercised when using correlation data. Also, correlation does not prove that one factor drives the other factor rather is shows there is a relationship. In order to be certain that a tissue concentration impacts yield or quality separate research needs to be conducted using cause and effect to determine how application of nutrients change tissue nutrient concentrations and whether yield or quality factors are impacted.
Correlations between individual nutrient concentrations and their respective soil test collected at the time of tissue sampling are summarized in Table 13. Significant positive correlations were found between the respective soil test and leaf and petiole tissue for nitrogen, nitrate-nitrogen, phosphorus, and potassium. Leaf blade and petiole calcium was correlated to the 6-24" soil test Ca content but not the 0-6" Ca soil test. There was no correlation between leaf tissue and soil test magnesium and sulfur. The strongest correlations were for the 0 to 6-inch depth but significant positive correlations were also found between tissue N and K and the 6-24 inches N soil test values. For micronutrients, there were no significant correlations between leaf blade and petiole micronutrient concentrations for many nutrients. Exceptions were leaf blade boron, petiole copper, and leaf blade zinc concentrations. Since the sites were maintained at high fertility levels it is not surprising that there was little correlation between soil test values and tissue nutrient concentration for micronutrients. Environmental factors such as temperature and precipitation and crop development at sampling have been shown to influence variation in nutrient concentration among research sites for other crops.

Average nutrient concentrations by location were regressed with multiple soil and environmental factors to determine if variation in tissue concentrations could be explained by variations in factors which cannot be controlled. Multiple environmental factors were studied including average minimum and maximum temperature, total precipitation, and growing degree day. All the previous factors were summarized based on the time from planting to sampling, 1 day, 3 days, 1 week, 2 weeks, and 3 weeks prior to sampling. Significant factors were grouped into long term (greater than 2 weeks) or short term (2 weeks or less) factors for summary in Figures 3 and 4. All soil factors in Tables 2a and 2b were utilized and were grouped into soil test or other soil (soil) factors after the analysis. Time factor considers the time (days) between planting and sampling. The remaining variation which could not be explained by the model was marked as unknown. Two micronutrients, iron and copper, were not regressed with soil factors as contamination of iron and copper through soil adhering to the plant tissue or foliar application of the nutrient due to greater than expected concentrations of either nutrient not as a result of plant uptake.

A total of 11 nutrients were examined for both the leaf blade and petiole samples for a total of 22 comparisons. Of the 22 comparisons, Long term climate factors explained the majority of variability in plant tissue concentration for 3 comparisons while short term factors provided the best explanation in one instance. Soil chemical and physical properties other than soil test values explained most variation in five instances. Time factors such as days after planting and growing degree day accumulation also represented the majority of variation in five instances. The soil test for a particular nutrient explained the largest portion of variation in nutrient concentrations in five instances. Three of the five instances were related to nitrogen (blade and petiole nitrate-N and petiole total N). Unknown factors explained the majority of variation in three of 22 instances. The fact that soil test for individual nutrients were not the most important factor in explaining most variation in tissue nutrient concentration indicate most variability in tissue concentration is dictated by factors out of human control. In most instances the variation in tissue concentration is likely related to stress factors not related to a specific nutrient availability thus correcting for tissue concentrations which are identified as low likely will not fully correct a nutrient deficiency. Taking multiple samples from different areas of fields to compare poorer with good plant growth would provide better data giving a comparison of nutrient concentrations in order to identify if a problem occurs rather than just a random sample collected in a field to search for nutrient deficiencies. It is likely that a nutrient deficiency will be found with a random sample within a field when using book values for nutrient concentrations but it is doubtful deficiencies identified in this way can be corrected.

Figure 7 summarizes the relationship between blade total N concentration and root yield, and blade total Ca concentration and recoverable sugar. Best fit models show a general relationship between the factors. However, in the case both graphs, clustering of values within sites result in the positive relationships and it is questioned how accurate a model developed to predict yield or quality can do so. Figure 8 shows the negative relationship between petiole Ca and root yield which demonstrates that positive relationships do not always exist between nutrient concentration and yield factors. Both graphs use actual yield and recoverable sugar values and prediction models typically use values relative to a maximum value in order to reduce the impact of random factors not accounted for in the model from influencing the relationship between yield or quality factors and tissue concentrations. For example, crop yield is an interaction between the varieties genetic potential and optimal growth factors at an individual site. Soil nutrient availability is one factor impacting yield but not the sole factor thus adjusting yield data. For this report yield data was not adjusted on a relative basis as it is unclear how to make adjustments when differences in yield are based on genetic factors only. With nutrient availability trials the maximum yield produced by increasing rates of nutrient applied are used to compare the yield produced by treatments to generate a relative yield as it relates to maximum yield potential by site for a specific cultivar.

The equations a through f below represent results from multiple regression analysis to determine if multiple factors combined can help predict root yield and recoverable sugar per ton. Equations a, b, and c identify significant prediction for root yield using plant tissue factors for sample times 1, 2, and 3, respectively. Equations e, f, and g identify prediction factors for recoverable sugar per ton for times 1, 2, and 3, respectively.

(a) root yield = -31.8 + 5.04(Blade N) + 1.28 (Blade B) – 0.000136 (Pet Cl)

(b) root yield = 57.0 – 27.7(Blade Mg) – 17.9 (Pet Ca) – 0.88 (Pet Cu)

(c) root yield = -20.7 + 0.82(Blade Zn) – 11.4 (Pet K) + 2.65 (Pet B)

(d) rec. sugar per ton = 80.6 -0.005(Blade NO3) + 20.9 (Blade P) -126.6 (Blade S) + 2.37 (Blade Zn) + 0.008 (Blade Cl) + 756.86 (Pet S)

(e) rec. sugar per ton = 446.6 – 213.9 (Blade Mg) – 332.7 (Blade S) + 1.09(Pet Mn)

(f) rec. sugar per ton = 351.7 – 183.3(Blade P) – 63.5(Blade Mg) – 0.17 (Blade Cu) + 1.41 (Blade Zn) – 80.4 (Pet Ca)

Table 14 summarized partial r^2 values for each nutrient in the above equations showing how much of the total variation is explained by individual leaf blade or petiole nutrient concentration deemed significant in the model. Time 1 prediction models could be used to predict 99% of the variability in yield and in recoverable sugar per ton with a combination of multiple factors. Combined r^2 values were poorer at time 2 compared to time 1 and for root yield at time 3 compared to time 1, but not for recoverable sugar at time 3 which had a total r^2 similar to Time 1. This indicates that prediction is generally better for Time 1 than the later sampling dates. What should be noted though is that all factors in the model do not necessarily have a positive impact on root yield or recoverable sugar. For example in equation a, root yield increased with increasing blade N and B concentration and decreasing petiole Cl content. One item to note is that there is some correlation between the different blade and petiole nutrient concentration as uptake of a single nutrient can impact the uptake of other nutrients. Also, prediction models are always better at backwards predicting values and seldom are good at forward predicting what may happen in future years. For example, many models exist to predict iron deficiency chlorosis in soybean but many fail to predict the severity and where IDC will occur when used in studies where the models did not generate data. Care should always be exercised when using multiple regression models as the data may be specific to the sites where the studies were conducted or cultivars used for the studies.

CONCLUSIONS

The data showed that there were clear differences in yield and quality among the sugarbeet varieties used in the study. Tissue (leaf blade and petiole) nutrient concentration will vary among sugarbeet varieties sampled in the same field at the same time. The concentration of most nutrients will decrease when sampling the same leaf relative to the top part of the canopy over time. The decrease or increase will occur for each nutrient similar for the leaf blade and petiole sample. Due to this variation, a large range in the recommended sampling time for leaf blade samples (50-80 days after planting) should not be used. The data indicates that earlier sampling around 40-50 days after planting may be more predictive of yield response compared to later samples. However, there was not strong evidence that root yield or recoverable sugar could be fully predicted by plant tissue concentration and that concentration of nutrients in leaf blade and petiole tissues could be explained by factors other than the soil test of a nutrient indicating much of the variation in plant tissue concentration is controlled by uncontrollable factors. The data indicates that significant caution should be exercised when collecting a single sample from a well fertilized field as there is no evidence that the concentration of a nutrient in the leaf or petiole has a direct impact on yield or quality.

References

Bryson, G.M., H.A. Mills, D.N. Sasseville, J. Benton Jones Jr., and A.V. Barker. 2014. Plant analysis handbook III: A guide to sampling, preparation, analysis, and interpretation for agronomic and horticultural crops. Micro-macro Publ. Inc., Athens, GA.

Kaiser, D.E., J.A. Lamb, and C.J. Rosen. 2013. Plant analysis sampling and interpretation. Ext. Publ. FO-3176-B. Univ. of MN Ext. St. Paul.

Kaiser. D.E., J.J. Wiersma, and J.A. Anderson. 2014b. Genotype and environment variation in elemental composition of spring wheat flag leaves. Agron. J. 106:324-336.

Sterrett, S.B., C.B. Smith. M.P. Mascianica, and K.T. Demchak. 1987. Comparison of analytical results from plant analysis laboratories. Commun. Soil Sci. Plant Anal. 18:287-299.

Table 1. Location, planting and sampling information, dominant soil series, and cation exchange capacity (CEC) for each location (CC, Clara City; H, Hector; LL, Lake Lillian; M, Murdock; R, Renville).

	Date of				Soil		CEC		Particle Size		
Location	Planting	Sample 1	Sample 2	Sample 3	Series	Classification‡	0-6”	6-24”	Sand	Silt	Clay
							meq/100g			%	
					2017						
CC	25-May	12-Jul	2-Aug	22-Aug	Colvin-Quam	T Calciaquoll	31.6	25.5	18	53	30
LL	8-May	21-Jun	12-Jul	2-Aug	Nicollet	A Hapludoll	33.7	28.7	25	40	35
M	29-Apr	21-Jun	12-Jul	2-Aug	Bearden-Quam	Ae Calciaquoll	28.0	22.2	14	48	38
R	6-May	21-Jun	11-Jul	1-Aug	Chetomba	T Endoaquoll	31.1	24.4	22	43	36
					2018						
CC	17-May	27-Jun	18-Jul	14-Aug	Bearden-Quam	Ae Calciaquoll	30.9	20.9	16	48	37
H	10-May	21-Jun	9-Jul	2-Aug	Crippin	A.P. Hapludoll	35.8	28.5	10	49	41
LL	7-May	21-Jun	9-Jul	2-Aug	Nicollet	A Hapludoll	31.3	23.7	30	37	33
M	18-May	27-Jun	16-Jul	14-Aug	Bearden-Quam	Ae Calciaquoll	35.2	28.2	11	48	41
					2019						
H	7-May	17-Jun	11-Jul	31-Jul	Crippin	A.P. Hapludoll	40.5	34.9	18	42	40
LL	6-May	17-Jun	11-Jul	31-Jul	Okaboji-Canisteo	C.V. Endoaquoll	36.0	30.9	13	50	37
M	31-May	15-Jul	31-Jul	19-Aug	Byrne-Buse	C. Hapludoll	27.7	23.9	21	50	29

‡A, aquic; Ae, aeric; A.P., aquic pachic; C, calcic; C.V., cuuulic vertic; T, typic.

Table 2a. Summary of 2017 soil test results for samples collected with plant tissue samples at Clara City (CC), Lake Lillian (LL), Murdock (M), and Renville (R).

					Ammonium Acetate				DTPA								
Time	Location	Depth	NO_3-N	P	Ca	K	Mg	SO_4-S	Cu	Fe	Mn	Zn	B	Cl	O.M.	pH	CCE
		in	ppm												-%-		-%-
1	CC	0-6	17.5	12	5852	242	832	12	1.0	7.8	18.1	2.7	1.2	11.2	7.0	7.9	27
		6-24	11.5	3	5058	153	1076	10	1.4	10.0	7.2	0.6	0.8	11.6	4.0	8.1	28
	LL	0-6	31.0	36	4833	182	562	15	1.0	43.8	29.5	0.9	0.6	8.6	6.2	7.0	0
		6-24	17.2	8	4679	153	548	11	1.2	43.5	17.3	0.6	0.6	8.6	4.7	7.0	2
	M	0-6	9.3	8	5960	189	696	12	1.0	7.1	18.6	1.9	1.6	7.8	5.3	8.0	32
		6-24	14.0	2	6330	163	869	133	1.2	6.4	8.0	0.8	1.0	6.7	3.1	7.8	31
	R	0-6	6.9	8	5152	348	583	12	1.4	17.2	29.9	1.6	0.9	9.6	5.1	7.5	2
		6-24	6.9	3	5581	217	608	8	1.4	9.2	11.3	0.5	0.6	7.7	3.1	7.9	11
2	CC	0-6	12.6	12	5938	249	817	11	1.0	7.3	14.7	2.7	1.3	6.9	6.6	8.0	28
		6-24	3.4	3	5139	134	1016	10	1.5	8.2	7.4	0.8	0.7	7.8	4.3	8.2	34
	LL	0-6	16.4	35	4772	156	523	14	1.0	36.0	26.4	0.8	0.5	6.7	6.0	7.3	3
		6-24	4.4	4	4480	138	543	10	1.3	40.7	16.3	0.4	0.5	6.9	4.2	7.1	0
	M	0-6	3.5	9	5877	163	657	11	1.1	7.6	15.3	1.9	1.5	8.0	5.2	8.1	33
		6-24	3.0	3	6824	155	717	160	1.2	6.2	7.6	0.8	1.1	6.8	3.5	7.8	32
	R	0-6	3.4	9	5126	316	537	11	1.3	12.1	24.0	1.4	0.8	9.0	5.2	7.7	1
		6-24	1.6	2	5280	147	693	6	1.4	8.2	8.2	0.3	0.6	9.8	2.9	8.0	10
3	CC	0-6	4.5	16	5957	214	801	11	1.0	8.0	14.0	2.8	0.9	8.6	6.6	8.0	29
		6-24	7.1	2	4835	138	1004	9	1.6	7.6	4.5	0.8	0.6	5.7	3.1	8.2	38
	LL	0-6	4.3	34	4718	142	545	14	1.1	39.6	23.3	1.0	0.6	7.6	6.2	7.3	0
		6-24	1.6	8	3552	135	550	12	1.2	46.0	20.7	0.4	0.7	7.4	4.7	6.8	0
	M	0-6	3.5	7	5943	169	667	11	1.3	6.2	13.4	2.0	1.2	7.1	5.2	8.1	34
		6-24	2.9	3	6236	156	723	61	1.3	5.8	6.5	1.0	1.1	7.5	3.5	7.9	30
	R	0-6	3.4	8	5034	312	558	11	1.4	15.0	22.6	1.4	0.8	8.6	5.2	7.6	1
		6-24	1.7	3	5539	188	688	8	1.4	10.0	10.0	0.4	0.6	8.4	3.2	7.8	6

CCE, calcium carbonate equivalency.

Table 2b. Summary of 2018 soil test results for samples collected with plant tissue samples at Clara City (CC), Hector (H), Lake Lillian (LL), and Murdock (M).

					Ammonium Acetate				DTPA								
Time	Location	Depth	NO_3-N	P	Ca	K	Mg	SO_4-S	Cu	Fe	Mn	Zn	B	Cl	O.M.	pH	CCE
		in	ppm												-%-		-%-
1	CC	0-6	4.9	10	8309	158	467	149	0.7	4.3	18.2	1.8	1.5	9.6	6.7	7.6	37
		6-24	4.3	2	9711	78	660	184	1.1	5.6	6.5	0.6	0.7	9.8	3.3	7.6	38
	H	0-6	14.0	9	6440	208	492	5	1.2	5.9	22.8	0.9	1.3	15.8	6.2	7.7	3
		6-24	9.9	2	5469	99	558	3	1.9	5.9	5.5	0.5	0.6	15.9	3.0	7.9	12
	LL	0-6	10.7	18	5262	200	556	6	0.9	10.8	26.6	1.2	0.8	18.4	5.0	7.7	3
		6-24	11.1	3	4783	106	654	7	1.2	7.3	8.5	0.5	0.5	16.6	2.7	7.7	9
	M	0-6	9.2	21	6191	178	807	10	1.1	6.0	17.4	1.6	1.4	14.1	5.7	7.8	8
		6-24	10.1	3	5343	123	1030	7	1.4	5.6	6.2	0.8	1.0	8.4	3.3	8.0	12
2	CC	0-6	4.3	10	7583	164	394	171	0.6	4.4	14.6	1.6	1.8	56.7	7.3	7.6	38
		6-24	5.5	3	13289	68	441	215	0.6	3.3	3.9	0.3	1.0	12.4	4.5	7.7	37
	H	0-6	3.5	8	6190	242	467	4	1.2	5.9	18.5	0.9	1.2	14.0	6.2	7.7	3
		6-24	2.2	2	5495	121	531	3	1.7	5.4	4.4	0.4	0.6	10.6	3.0	7.9	14
	LL	0-6	2.8	15	5189	156	521	6	0.8	10.0	21.9	1.0	0.8	13.0	5.0	7.8	2
		6-24	6.0	2	5194	114	699	4	1.1	7.6	8.4	0.4	0.6	12.6	3.0	7.7	10
	M	0-6	3.2	10	5993	179	780	5	1.0	5.5	11.7	1.5	1.5	12.8	5.6	7.8	8
		6-24	3.2	3	5022	102	944	5	1.3	5.3	3.7	0.7	0.9	34.2	3.0	8.0	15
3	CC	0-6	2.8	9	7018	162	488	79	0.6	4.1	7.3	1.7	1.5	41.7	7.2	7.6	36
		6-24	1.7	2	10821	66	616	121	0.9	3.1	2.6	0.3	0.9	10.7	3.9	7.7	39
	H	0-6	2.1	6	6284	183	478	4	1.2	5.6	12.8	0.8	1.0	16.8	6.3	7.8	4
		6-24	1.0	1	5773	88	565	3	1.7	5.2	3.9	0.3	0.8	19.8	3.4	7.9	10
	LL	0-6	1.9	14	4942	159	543	5	0.9	10.9	19.1	1.1	0.7	7.5	5.1	7.7	3
		6-24	1.1	1	4837	98	682	4	1.0	7.5	6.9	0.3	0.6	11.1	2.9	7.8	8
	M	0-6	2.3	11	5997	150	771	5	1.0	5.3	6.9	1.5	1.2	8.4	5.8	7.9	7
		6-24	1.8	3	5143	118	937	6	1.3	4.7	2.9	0.7	1.0	16.3	3.3	8.1	15

CCE, calcium carbonate equivalency.

Table 2c. Summary of 2019 soil test results for samples collected with plant tissue samples at Hector (H), Lake Lillian (LL), and Murdock (M).

					Ammonium Acetate				DTPA								
Time	Location	Depth	NO_3-N	P	Ca	K	Mg	SO_4-S	Cu	Fe	Mn	Zn	B	Cl	O.M.	pH	CCE
		in	ppm												-%-		-%-
1	H	0-6	10.2	28	6201	289	629	9	1.6	20.0	27.8	1.8	0.8	12.9	7.7	7.7	0
		6-24	7.4	5	5926	210	770	8	1.9	22.1	13.4	0.9	0.6	13.4	5.4	7.3	1
	LL	0-6	4.5	36	6467	307	642	6	1.6	19.9	25.4	1.7	0.6	12.6	7.4	7.4	4
		6-24	7.4	4	5067	217	830	5	2.0	20.8	8.8	0.5	0.6	11.2	4.4	7.1	8
	M	0-6	3.4	27	6018	271	611	7	2.0	21.2	21.2	1.9	0.8	10.1	7.6	7.6	7
		6-24	7.4	8	5652	219	817	5	2.0	25.3	11.6	1.3	0.7	10.7	5.4	7.3	4
2	H	0-6	22.5	14	7521	240	881	10	1.4	13.4	15.9	1.2	1.0	12.6	7.2	7.2	0
		6-24	7.5	3	6454	196	1178	10	1.8	11.0	5.2	0.5	0.6	11.5	3.7	7.6	0
	LL	0-6	4.3	18	7589	251	803	9	1.3	14.3	15.5	1.4	1.0	11.4	7.3	7.3	6
		6-24	7.7	3	6447	225	1121	5	1.7	12.4	4.4	0.4	0.6	11.9	3.5	7.7	9
	M	0-6	3.1	12	7294	205	824	5	1.3	12.3	11.9	1.8	1.2	13.5	7.4	7.4	8
		6-24	7.6	2	6338	220	1130	5	1.8	13.4	3.6	1.1	0.6	13.0	3.5	7.7	10
3	H	0-6	18.6	8	6122	226	639	7	1.2	11.4	14.5	2.1	0.8	10.1	5.0	5.0	0
		6-24	7.7	2	5019	212	833	6	1.4	11.6	6.0	0.8	0.5	10.0	2.8	7.7	0
	LL	0-6	8.1	7	5949	212	630	4	1.3	12.7	13.3	2.3	0.8	11.5	4.8	4.8	5
		6-24	7.8	2	5497	193	848	4	1.6	11.3	5.6	1.1	0.4	10.9	2.7	7.8	9
	M	0-6	2.0	7	6205	209	650	6	2.3	12.4	13.6	4.5	0.9	9.0	5.0	5.0	8
		6-24	7.7	2	5390	201	806	6	1.4	11.7	4.8	0.8	0.5	8.1	2.6	7.8	6

CCE, calcium carbonate equivalency.

Table 3a. Summary of analysis of variance for the main effect of sugarbeet variety by and across 2017 locations. Numbers within rows which are followed by the same letter are not significantly different at $P \leq 0.10$.

	Variety						
Location	Crystal RR018	Maribo 109	Beta 92RR30	Beta 9475	Crystal M579	Crystal M509	*P*>F
	---------------------------------------Root Yield (tons/acre) ---------------------------------------						
Clara City	26.8a	23.0ab	19.2b	26.6a	26.2a	25.1a	0.06
Lake Lillian	33.6b	29.0c	28.0c	33.9b	35.0b	38.2a	<0.001
Murdock	37.4b	36.7b	33.2c	37.6b	35.5bc	41.7a	<0.001
Renville	32.6b	29.1c	30.0c	34.3ab	35.0a	36.3a	<0.001
Average	32.5b	29.3c	27.8d	33.1b	32.9b	35.4a	<0.001
	---------------------------------------Recoverable Sugar (lbs/ton) ---------------------------------------						
Clara City	266bc	278ab	272b	272bc	289a	260c	0.01
Lake Lillian	269a	268a	257b	263ab	270a	249c	<0.001
Murdock	294ab	289bc	297ab	288bc	305a	280c	0.04
Renville	285cd	295b	302a	293b	289bc	280d	<0.01
Average	280b	283b	281b	279b	288a	267c	<0.001
	---------------------------------------Recoverable Sugar (lbs/acre) ---------------------------------------						
Clara City	7130ab	6413bc	5278c	7254ab	7561a	6555ab	0.05
Lake Lillian	9056a	7789b	7185b	8912a	9421a	9526a	<0.001
Murdock	11011b	10614b	9837c	10820b	10832b	11673	<0.01
Renville	9282bc	8590c	9067c	10014ab	10125a	10173a	<0.01
Average	9110a	8300b	7873c	9265a	9489a	9490a	<0.001

Table 3b. Summary of analysis of variance for the main effect of sugarbeet variety by and across 2018 locations. Numbers within rows which are followed by the same letter are not significantly different at $P \leq 0.10$.

Location	Variety: Crystal RR018	Maribo 109	Beta 92RR30	Beta 9475	Crystal M579	Crystal M509	*P*>F
	---Root Yield (tons/acre)---						
Clara City	15.9b	13.6c	18.6a	16.9ab	17.4ab	18.6a	0.01
Hector	27.7c	29.8b	30.1b	31.1b	30.4b	35.8a	<0.001
Lake Lillian	--	--	--	--	--	--	--
Murdock	28.1c	28.0c	27.9c	32.0b	30.8b	35.0a	<0.001
Average	23.9c	23.8c	25.5b	26.7b	26.2b	29.8a	<0.001
	---Recoverable Sugar (lbs/ton)---						
Clara City	231	235	242	219	239	229	0.12
Hector	247	251	250	251	260	249	0.62
Lake Lillian	257	263	262	260	267	252	0.14
Murdock	265	278	273	263	282	271	0.11
Average	250b	257a	257a	248b	262a	250b	<0.001
	---Recoverable Sugar (lbs/acre)---						
Clara City	3679bc	3181c	4525a	3721bc	4153ab	4273ab	0.02
Hector	6859c	7478b	7537b	7796b	7915b	8908a	<0.001
Lake Lillian	--	--	--	--	--	--	--
Murdock	7440d	7771cd	7616d	8412bc	8683b	9495a	<0.001
Average	5992c	6143c	6559b	6643b	6917b	7558a	<0.001

Table 3c. Summary of analysis of variance for the main effect of sugarbeet variety by and across 2019 locations. Numbers within rows which are followed by the same letter are not significantly different at $P \leq 0.10$.

Location	Variety						P>F
	Crystal RR018	Maribo 109	Beta 92RR30	Beta 9475	Crystal M579	Crystal M509	
	---Root Yield (tons/acre)---						
Hector	24.1ab	18.4b	26.0a	28.9a	26.2a	29.4a	0.05
Lake Lillian	33.8bc	32.1c	33.4bc	35.7b	33.3c	42.0a	<0.001
Murdock	23.6c	22.9c	20.9d	25.2b	26.0b	28.9a	<0.001
Average	27.2c	24.5d	26.8c	29.9b	28.5bc	33.4a	<0.001
	---Recoverable Sugar (lbs/ton)---						
Hector	258	236	259	255	266	243	0.22
Lake Lillian	278b	279b	285a	282ab	283ab	267c	<0.001
Murdock	263c	288a	296a	286ab	290a	270bc	0.03
Average	265bc	268bc	280a	274ab	280a	260c	<0.01
	---Recoverable Sugar (lbs/acre)---						
Hector	6555	4397	6768	7391	6982	7120	0.14
Lake Lillian	9401c	8974c	9490bc	10067b	9421bc	11199a	<0.001
Murdock	6182d	6595cd	6186d	7187bc	7528ab	7799a	<0.001
Average	7346cd	6722d	7481c	8215ab	7977bc	8706a	<0.001

Table 4. Summary of analysis of variance for leaf blade nutrient concentration averaged across eight locations from 2017-2019 and three sampling times at each location.

Nutrient	Time (T)	Location (L)	T x L	Variety (V)	T x V	L x V	T x L x V
		----------	----------	*P*>F	----------	----------	
Total-N	*	0.10	0.16	0.14	0.60	0.56	0.59
Nitrate-N	***	***	***	***	***	***	***
Phosphorus	0.08	0.15	0.19	0.09	0.51	0.58	0.64
Potassium	***	0.18	***	***	***	0.06	0.01
Calcium	***	***	***	***	***	0.11	***
Magnesium	***	0.21	***	***	***	***	**
Sulfur	0.14	0.17	0.14	0.12	0.35	0.49	0.54
Boron	0.15	0.18	0.25	0.13	0.33	0.42	0.58
Copper	***	***	***	***	***	**	***
Iron	***	***	***	***	**	0.05	**
Manganese	**	***	***	***	***	*	***
Zinc	**	***	***	***	*	0.44	0.51
Chloride	***	***	***	***	*	*	0.18

†Asterisks represent significance at *P*<0.05,*; 0.01, **; and 0.001, ***.

Table 5. Summary of analysis of variance for petiole nutrient concentration averaged across eight locations from 2017-2018 and three sampling times at each location.

Nutrient	Time (T)	Location (L)	T x L	Variety (V)	T x V	L x V	T x L x V
		----------	----------	*P*>F	----------	----------	
Total-N	***	***	***	***	***	0.24	0.15
Nitrate-N	***	***	***	***	***	0.06	*
Phosphorus	0.38	0.17	0.28	0.07	0.45	0.57	0.58
Potassium	*	0.17	0.13	0.15	0.31	0.57	0.61
Calcium	***	***	***	***	***	**	0.17
Magnesium	***	***	***	***	***	***	***
Sulfur	0.10	0.10	0.35	0.23	0.50	0.64	0.56
Boron	***	0.11	***	***	**	0.20	0.38
Copper	0.11	0.14	0.25	0.34	0.46	0.53	0.48
Iron	*	0.21	0.11	0.38	0.32	0.48	0.53
Manganese	*	0.34	0.13	0.12	0.37	0.51	0.57
Zinc	0.13	0.27	0.42	0.57	0.78	0.65	0.69
Chloride	*	***	***	***	0.1	0.27	0.41

†Asterisks represent significance at *P*<0.05,*; 0.01, **; and 0.001, ***.

Table 6. Varietal differences in leaf blade nutrient concentration across eleven locations from 2017-2019 and three sampling times at each location. Within rows, numbers followed by the same letter are not significantly different at $P \leq 0.10$.

	Variety						
Nutrient	Crystal RR018	Maribo 109	Beta 92RR30	Beta 9475	Crystal M579	Crystal M509	Suffic.†
			---% ---				
Total-N	5.25a	4.87b	4.84b	4.88b	4.79b	4.87b	4.3-5.0
Phosphorus	0.53a	0.55a	0.46c	0.48bc	0.45c	0.51ab	0.45-1.1
Potassium	3.95a	3.74b	3.63d	3.62d	3.71bc	3.65cd	2.0-6.0
Calcium	0.68b	0.74a	0.73a	0.65c	0.67bc	0.69b	0.5-1.5
Magnesium	0.48d	0.52b	0.56a	0.50c	0.50c	0.52b	0.25-1
Sulfur	0.38	0.36	0.35	0.37	0.36	0.38	0.21-0.5
			---ppm---				
Nitrate-N	752a	400e	609bc	634b	478d	580c	
Boron	30	31	32	29	30	29	31-200
Copper	35c	40a	36bc	33c	39ab	33c	11-40
Iron	494a	389c	502a	439b	516a	516a	60-140
Manganese	65cd	68b	76a	63d	79a	67bc	26-360
Zinc	46ab	39c	44ab	44b	44ab	47a	10-80
Chloride	3059b	3516a	3076b	3117b	2996bc	2895c	

†Suffic, sufficiency range identified by Bryson et al., 2014.

Table 7. Varietal differences in petiole nutrient concentration across eleven locations from 2017-2019 and three sampling times at each location. Within rows, numbers followed by the same letter are not significantly different at $P \leq 0.10$.

	Variety					
Nutrient	Crystal RR018	Maribo 109	Beta 92RR30	Beta 9475	Crystal M579	Crystal M509
			---% ---			
Total-N	2.54bc	2.60ab	2.65a	2.52cd	2.46d	2.61ab
Phosphorus	0.35bc	0.43a	0.35bc	0.35bc	0.33c	0.37b
Potassium	4.56	4.58	4.28	4.40	4.29	4.76
Calcium	0.44c	0.56a	0.49b	0.45c	0.49b	0.57a
Magnesium	0.26b	0.28a	0.28a	0.24d	0.24c	0.24c
Sulfur	0.14	0.15	0.13	0.14	0.14	0.14
			---ppm---			
Nitrate-N	4311c		5315a	4281c	3997c	4777b
Boron	23c	25s	24b	24b	23c	26a
Copper	9.6	9.5	8.6	9.9	9.0	9.5
Iron	307	300	267	257	289	285
Manganese	28b	29b	28b	26b	34a	30b
Zinc	20	21	18	18	19	20
Chloride	4980b		5880a	5742a	5665a	6103a

Table 8. Summary of leaf blade tissue concentration across locations and sugarbeet varieties from 2017-2019 and three sampling times at each location. Within rows, numbers followed by the same letter are not significantly different at $P \leq 0.10$.

	Sampling 1			Sampling 2			Sampling 3		
Nutrient	25%	50%	75%	25%	50%	75%	25%	50%	75%
					%				
Total-N	4.9	5.5	5.8	4.5	4.9	5.4	4.0	4.5	5.1
Phosphorus	0.44	0.54	0.64	0.42	0.51	0.62	0.34	0.42	0.51
Potassium	3.4	4.1	4.7	2.9	3.2	3.7	3.3	3.6	4.0
Calcium	0.66	1.09	1.34	0.41	0.52	0.75	0.32	0.42	0.57
Magnesium	0.49	0.77	0.98	0.32	0.39	0.52	0.27	0.31	0.43
Sulfur	0.33	0.36	0.40	0.31	0.35	0.39	0.33	0.37	0.41
					ppm				
Boron	26	28	31	27	30	34	28	31	34
Copper	9.1	11.1	14.9	11.7	14.4	18.5	21.6	48.7	118.0
Iron	274	505	763	230	423	874	113	151	221
Manganese	59	77	87	49	59	79	37	51	92
Zinc	37	44	48	36	45	51	35	41	49

Table 9. Summary of petiole tissue concentration across locations and sugarbeet varieties from 2017-2019 and three sampling times at each location. Within rows, numbers followed by the same letter are not significantly different at $P \leq 0.10$.

	Sampling 1			Sampling 2			Sampling 3		
Nutrient	25%	50%	75%	25%	50%	75%	25%	50%	75%
					%				
Total-N	3.0	3.7	4.0	1.9	2.4	3.1	1.2	1.6	2.4
Phosphorus	0.30	0.36	0.44	0.31	0.36	0.42	0.28	0.35	0.41
Potassium	4.8	5.5	6.4	3.4	3.9	4.6	3.2	3.7	4.2
Calcium	0.43	0.74	0.95	0.26	0.34	0.47	0.24	0.31	0.43
Magnesium	0.26	0.37	0.47	0.16	0.19	0.25	0.14	0.17	0.22
Sulfur	0.13	0.15	0.18	0.10	0.13	0.16	0.09	0.11	0.16
					ppm				
Boron	22	24	29	21	23	25	20	22	23
Copper	6.5	7.7	9.0	6.1	8.6	10.7	8.1	9.9	13.0
Iron	288	439	672	93	160	359	26	38	75
Manganese	29	37	44	20	26	33	17	21	26
Zinc	18	22	27	14	18	23	10	13	18

Table 10. Simple correlation (r) between sugarbeet root yield and leaf blade and petiole nutrient concentration for the newest fully developed leaf sampled 44, 65, and 87 days after planting. Correlation r values when between -0.11 and 0.11 are not considered significant at $P \leq 0.10$.

	N	NO_3	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Cl
Time 1 Blade	0.59	0.33	0.27	-0.08	-0.05	0.28	-0.22	0.21	0.07	0.39	-0.12	0.11	-0.27
Time 1 Petiole	0.73	0.39	0.34	0.38	-0.37	0.30	0.10	0.48	0.43	0.19	0.13	0.53	-0.29
Time 2 Blade	0.28	0.12	0.33	-0.33	-0.48	-0.32	0.03	-0.17	-0.01	0.16	-0.13	0.11	-0.18
Time 2 Petiole	-0.05	0.18	0.28	-0.54	-0.61	-0.11	-0.02	0.04	-0.17	-0.02	-0.17	-0.10	-0.26
Time 3 Blade	0.10	0.07	-0.10	0.04	-0.26	-0.14	0.22	0.11	-0.21	-0.28	0.08	0.13	-0.11
Time 3 Petiole	-0.15	-0.02	0.01	-0.33	-0.32	-0.18	-0.08	0.11	-0.11	-0.23	-0.18	-0.17	-0.17

Table 11. Simple correlation (r) between sugarbeet sugar content (pounds per ton) and leaf blade and petiole nutrient concentration for the newest fully developed leaf sampled 44, 65, and 87 days after planting. Correlation r values when between -0.11 and 0.11are not considered significant at $P \leq 0.10$.

	N	NO_3	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Cl
Time 1 Blade	0.47	-0.10	0.24	-0.13	-0.49	-0.21	-0.22	0.35	0.34	-0.03	-0.32	0.37	-0.15
Time 1 Petiole	0.40	0.13	0.31	-0.01	-0.61	-0.07	0.04	0.38	0.45	-0.17	-0.30	0.34	-0.20
Time 2 Blade	0.08	-0.26	0.09	-0.02	-0.29	-0.32	-0.13	-0.15	0.35	0.23	-0.02	0.18	0.15
Time 2 Petiole	0.09	-0.13	0.18	-0.16	-0.46	0.04	0.16	0.10	0.12	0.16	0.09	-0.04	-0.07
Time 3 Blade	0.05	-0.14	-0.21	0.20	0.05	0.01	0.05	0.04	-0.36	0.06	0.33	0.37	0.19
Time 3 Petiole	-0.07	-0.03	-0.21	-0.12	-0.10	0.04	-0.02	-0.09	-0.19	0.09	0.22	0.02	0.15

Table 12. Simple correlation (r) between sugarbeet sugar production (pounds per acre) and leaf blade and petiole nutrient concentration for the newest fully developed leaf sampled 44, 65, and 87 days after planting. Correlation r values when between -0.15 and 0.15 are not considered significant at $P \leq 0.10$.

	N	NO_3	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Cl
Time 1 Blade	0.60	0.22	0.30	-0.08	-0.16	0.18	-0.26	0.29	0.13	0.34	-0.19	0.18	-0.24
Time 1 Petiole	0.69	0.31	0.34	0.30	-0.47	0.22	0.08	0.51	0.46	0.10	0.01	0.53	-0.30
Time 2 Blade	0.24	0.01	0.29	-0.28	-0.49	-0.39	-0.01	-0.18	0.06	0.18	-0.13	0.14	-0.10
Time 2 Petiole	-0.05	0.08	0.27	-0.50	-0.63	-0.11	0.02	0.06	-0.12	0.01	-0.13	-0.10	-0.22
Time 3 Blade	0.09	0.01	-0.14	0.11	-0.19	-0.11	0.21	0.12	-0.28	-0.23	0.16	0.22	-0.02
Time 3 Petiole	-0.16	-0.04	-0.06	-0.31	-0.28	-0.16	-0.08	0.07	-0.16	-0.20	-0.10	-0.14	-0.09

Table 13. Correlation between leaf blade and petiole nutrient concentration across locations and sample time with the soil test concentration for the same nutrient for soil samples collected at 0-6 and 6-24 inch soil depths.

Nutrient	Plant Part	0-6" Soil Test	6-24" Soil Test
Nitrogen	Leaf Blade	0.49	0.61
	Petiole	0.54	0.75
Nitrate-N	Leaf Blade	0.56	0.67
	Petiole	0.54	0.68
Phosphorus	Leaf Blade	0.43	0.38
	Petiole	0.34	0.35
Potassium	Leaf Blade	0.59	0.35
	Petiole	0.57	0.35
Calcium	Leaf Blade	0.29	0.30
	Petiole	0.43	0.43
Magnesium	Leaf Blade	-0.17	-0.24
	Petiole	-0.02	-0.10
Sulfur	Leaf Blade	0.13	0.03
	Petiole	-0.11	-0.10
Boron	Leaf Blade	0.37	0.49
	Petiole	-0.03	0.03
Copper	Leaf Blade	-0.12	-0.12
	Petiole	0.51	0.36
Iron	Leaf Blade	0.08	0.06
	Petiole	0.07	0.05
Manganese	Leaf Blade	0.29	0.30
	Petiole	0.38	0.21
Zinc	Leaf Blade	0.35	0.65
	Petiole	0.18	0.47
Chloride	Leaf Blade	-0.01	-0.22
	Petiole	0.24	-0.07

Correlations between -0.30 and 0.30 are not significant at $P \leq 0.10$

Table 14. Correlation between leaf blade and petiole nutrient concentration across locations and sample time with the soil test concentration for the same nutrient for soil samples collected at 0-6 and 6-24 inch soil depths.

	Root Yield		Recoverable Sugar (ton)	
DAP	Tissue	Partial R^2	Tissue	Partial R^2
44	Blade N	0.88	Blade Zn	0.58
	Blade B	0.11	Blade S	0.24
	Pet Cl	0.003	Blade P	0.11
		0.99	Blade NO3	0.04
			Pet S	0.02
			Blade Cl	0.01
				0.99
65	Pet Ca	0.55	Blade Mg	0.33
	Pet Cu	0.17	Blade S	0.27
	Blade Mg	0.10	Pet Mn	0.26
		0.82		0.86
87	Pet K	0.30	Blade P	0.61
	Blade Zn	0.23	Blade Mg	0.06
	Pet B	0.31	Blade Cu	0.09
		0.84	Blade Zn	0.11
			Pet Ca	0.11
				0.98

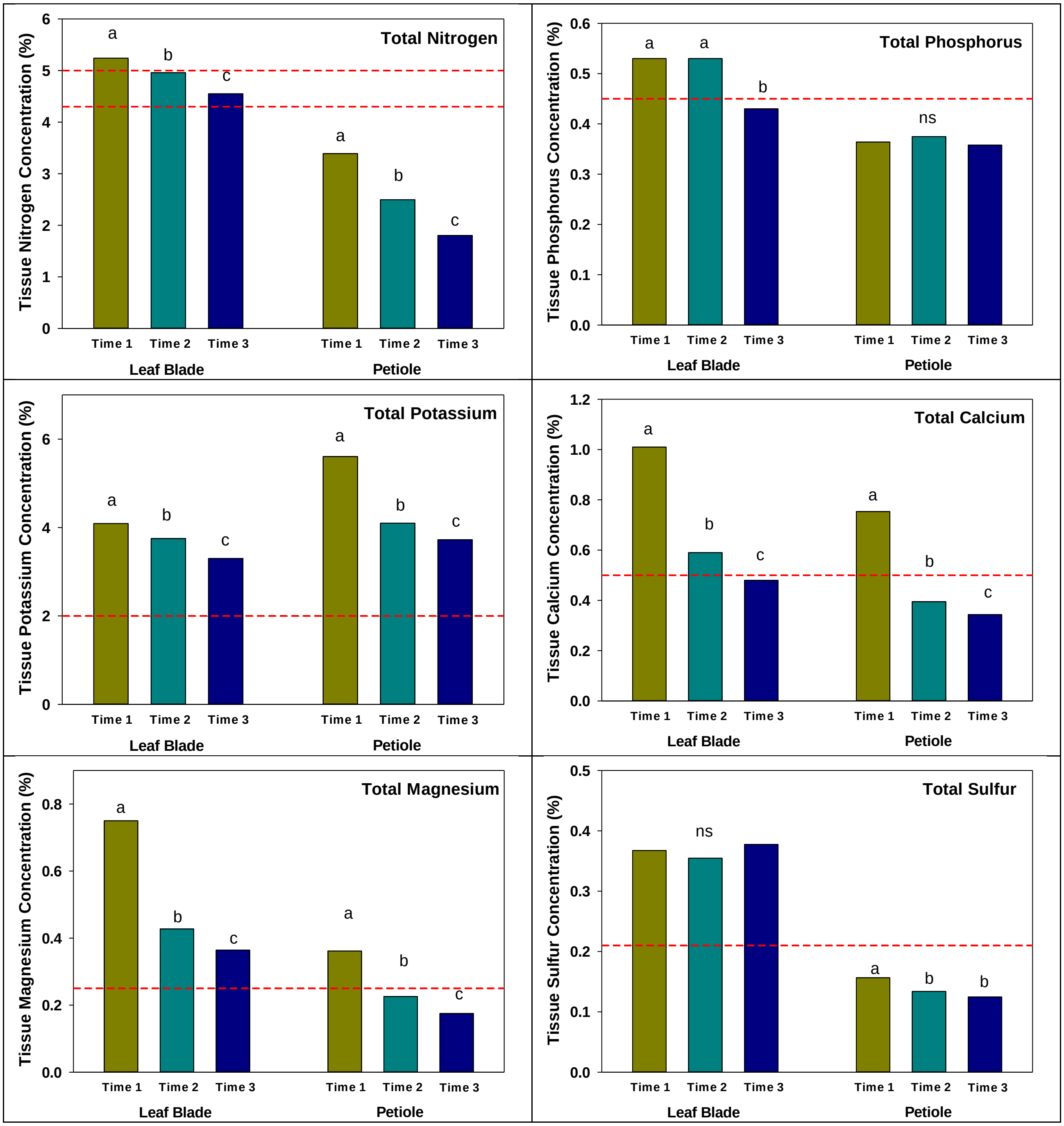


Figure 1. Summary of the impact of time on sugarbeet total macronutrient concentrations for leaf blade and petiole samples collected from six sugarbeet varieties. Letters denote significance among sampling times for leaf blade or petiole samples at $P \leq 0.10$. Horizontal dashed lines represent the upper and lower end of the sufficiency range for leaf blade samples according to Bryson et al., 2014. A single dashed line represents the low end of the sufficiency range.

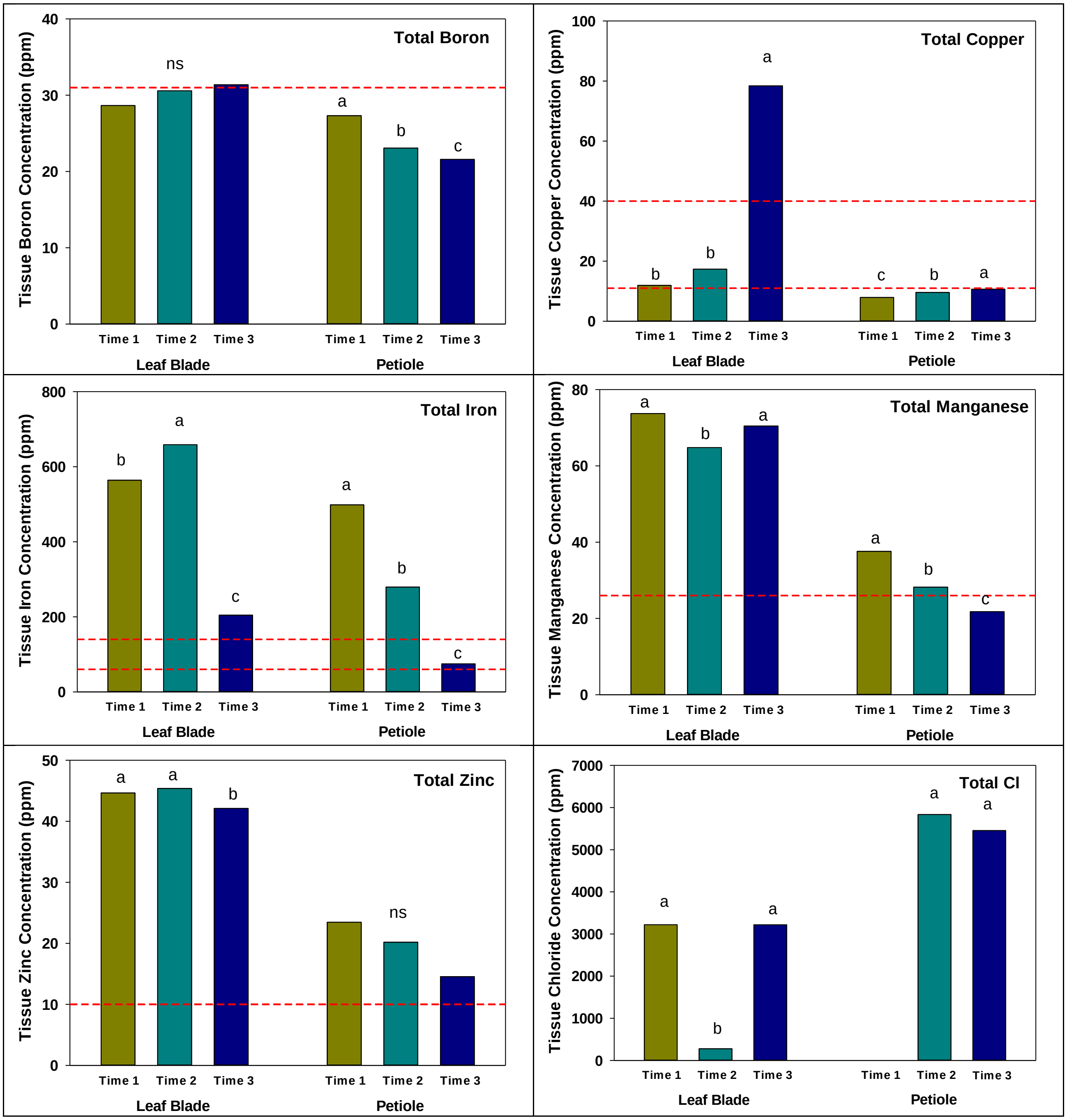


Figure 2. Summary of the impact of time on sugarbeet total micronutrient concentrations for leaf blade and petiole samples collected from six sugarbeet varieties. Letters denote significance among sampling times for leaf blade or petiole samples at $P \leq 0.10$. Horizontal dashed lines represent the upper and lower end of the sufficiency range for leaf blade samples according to Bryson et al., 2014. A single dashed line represents the low end of the sufficiency range.

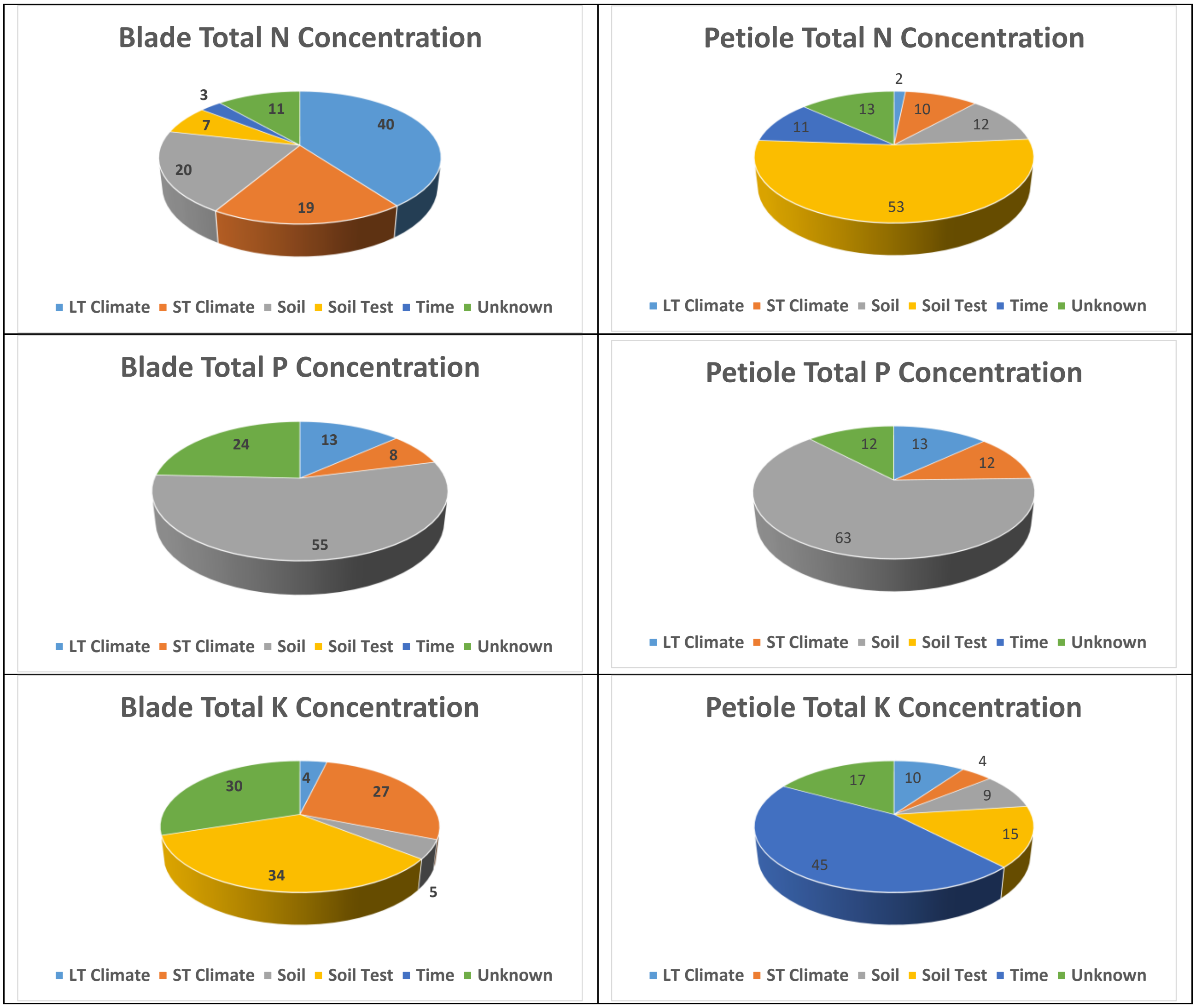
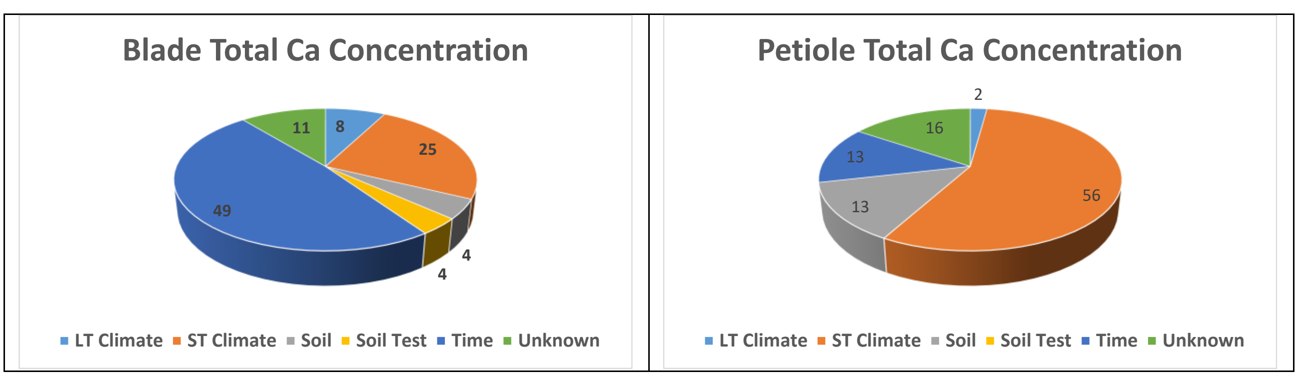


Figure 3. Summary of multiple regression output summarizing climate and soil relationships prediction of sugarbeet primary macro-nutrient concentration. Long term (LT) climate factors represent temperature averages or precipitations total of greater than 2 week or greater while short term (ST) represent totals 2 weeks or less. Unknown factors represent the portion of the R^2 not predicted by the model.



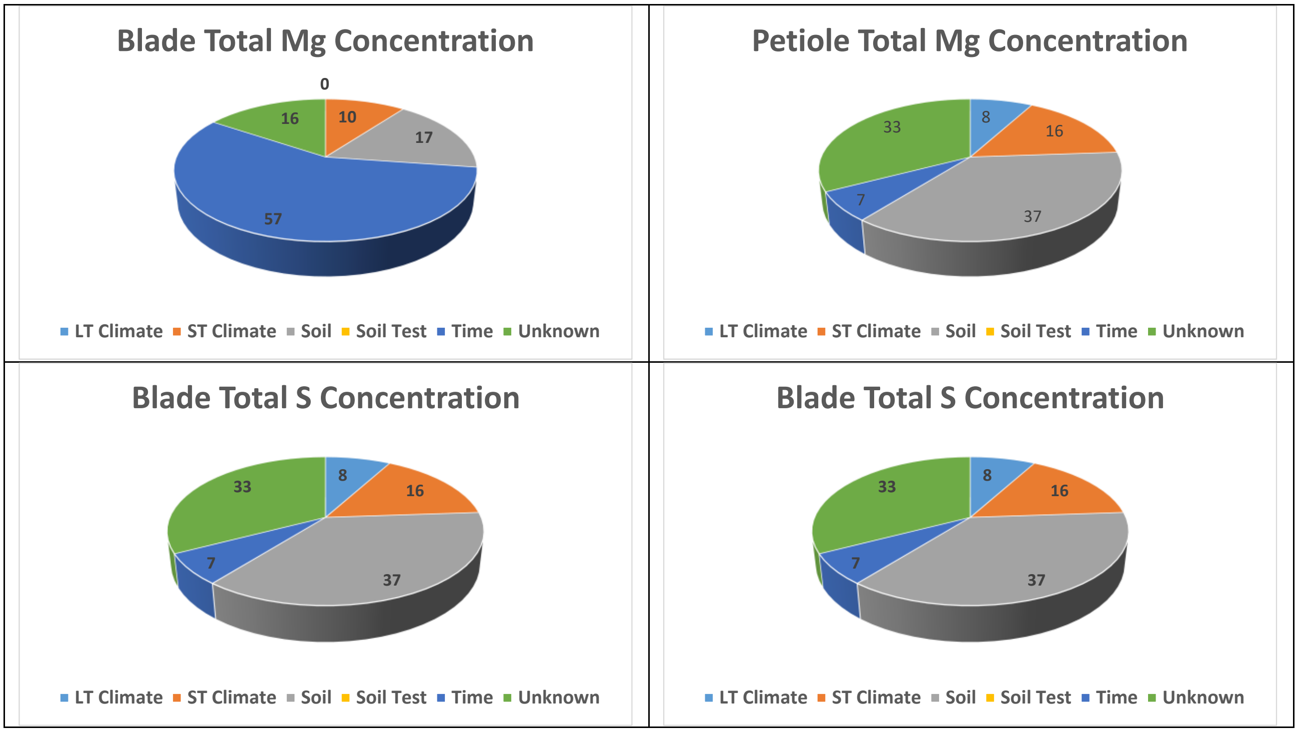
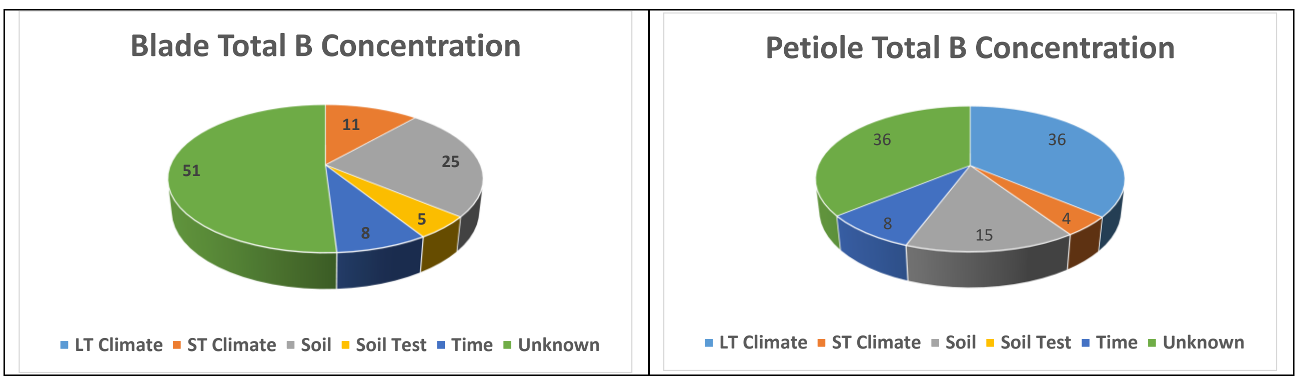


Figure 4 Summary of multiple regression output summarizing climate and soil relationships prediction of sugarbeet secondary macro-nutrient concentration. Long term (LT) climate factors represent temperature averages or precipitations total of greater than 2 week or greater while short term (ST) represent totals 2 weeks or less. Unknown factors represent the portion of the R^2 not predicted by the model.



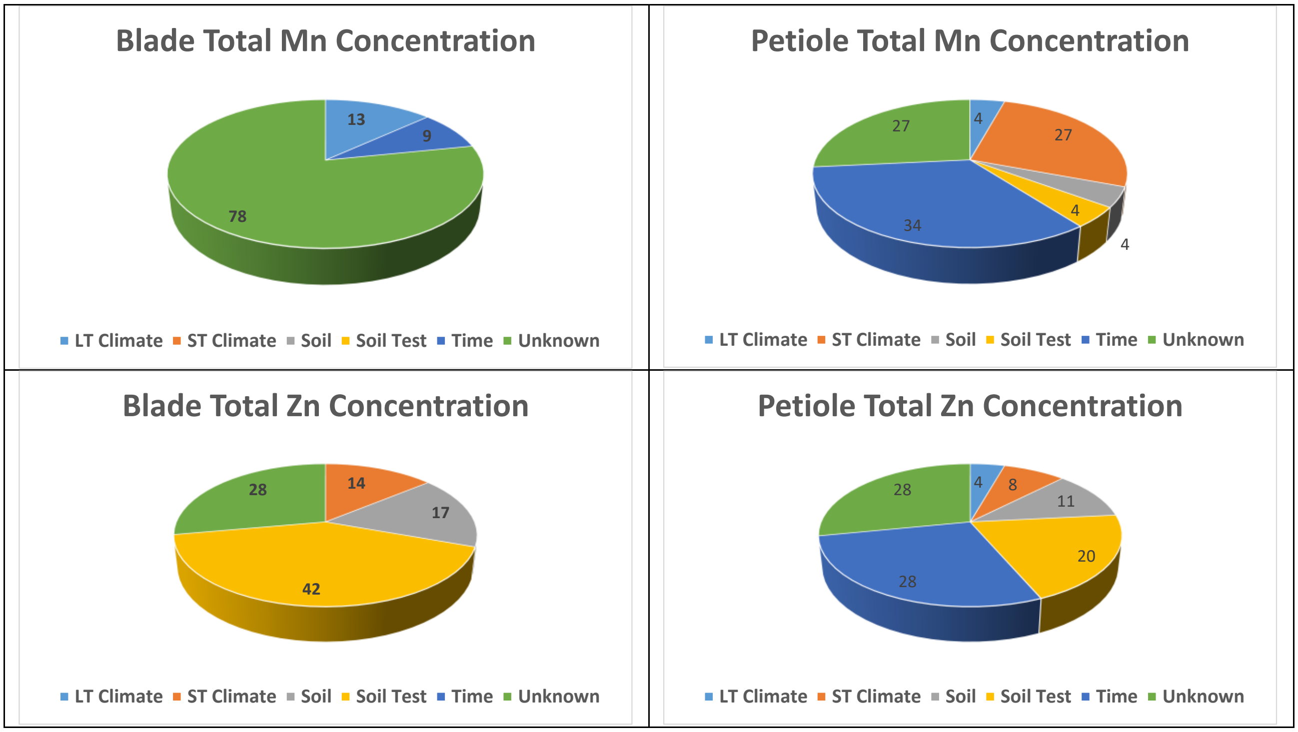


Figure 5. Summary of multiple regression output summarizing climate and soil relationships prediction of sugarbeet micro-nutrient concentration. Long term (LT) climate factors represent temperature averages or precipitations total of greater than 2 week or greater while short term (ST) represent totals 2 weeks or less. Unknown factors represent the portion of the R^2 not predicted by the model.

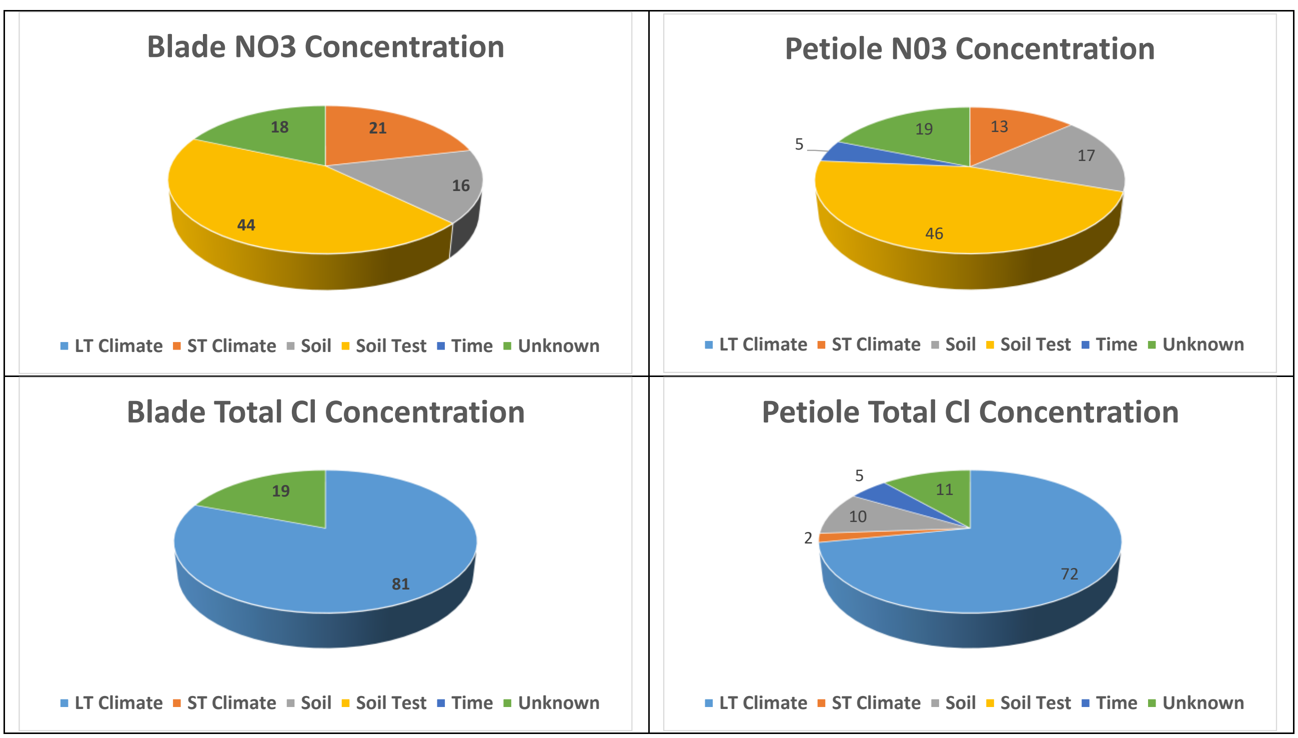
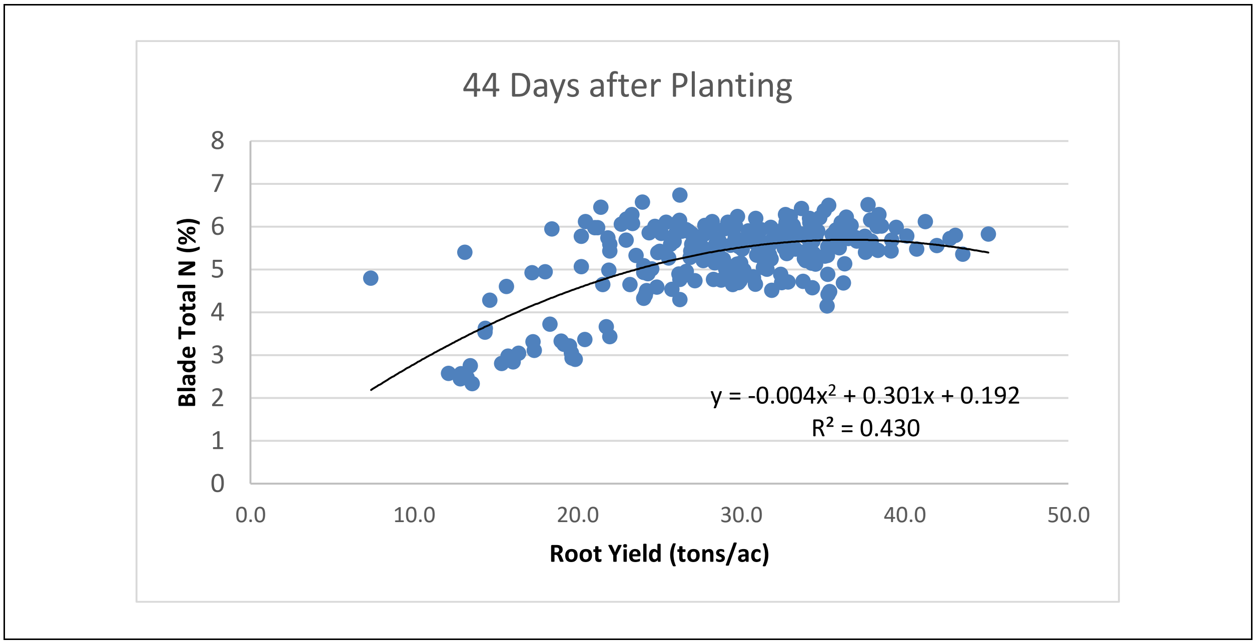


Figure 6. Summary of multiple regression output summarizing climate and soil relationships prediction of sugarbeet nitrate nitrogen and chloride concentration. Long term (LT) climate factors represent temperature averages or precipitations total of greater than 2 week or greater while short term (ST) represent totals 2 weeks or less. Unknown factors represent the portion of the R^2 not predicted by the model.



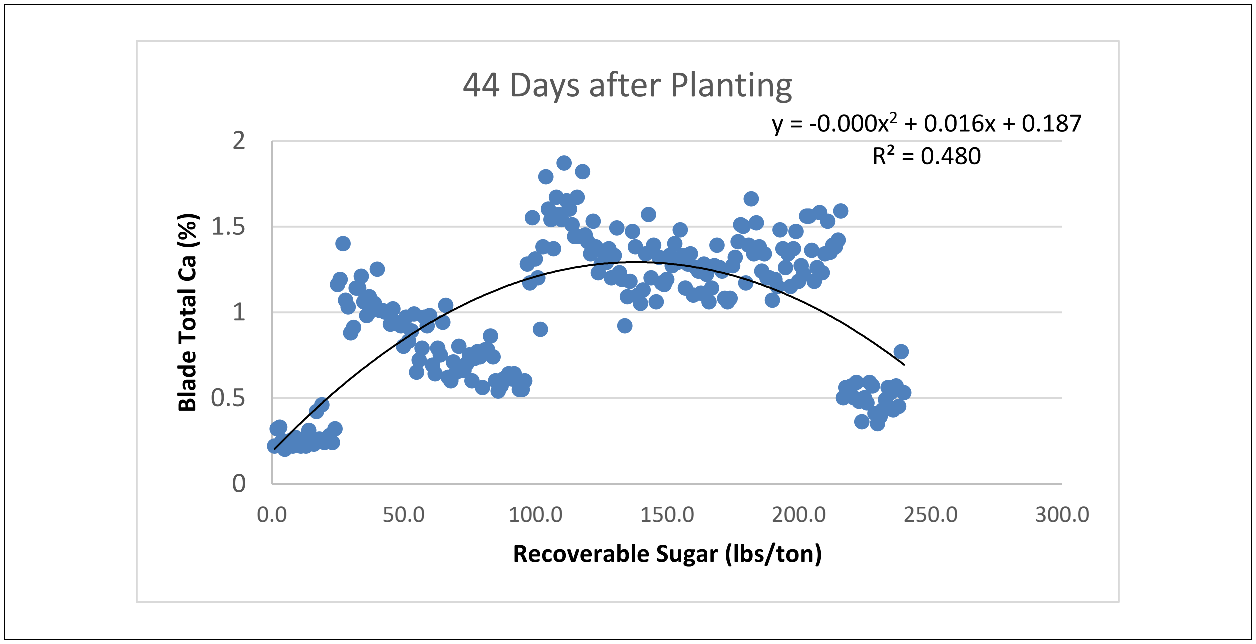


Figure 7. Relationship between blade total N concentration and root yield and blade total Ca concentration on recoverable sugar for tissue samples collected 44 days after planting.

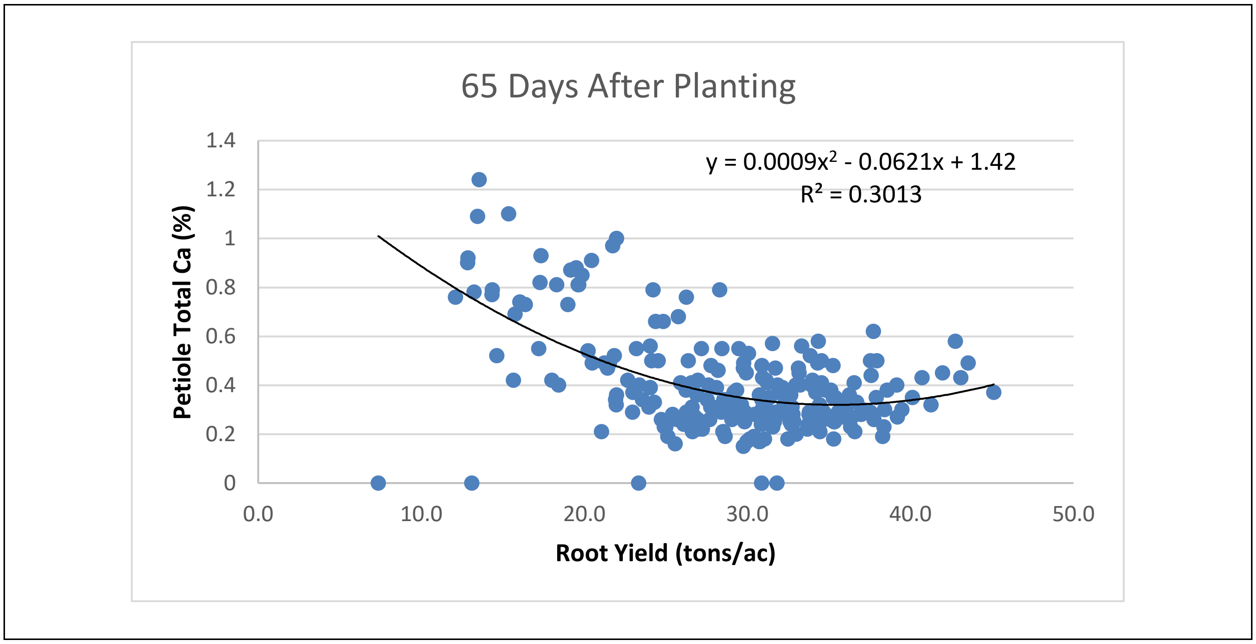


Figure 8. Relationship between petiole total Ca concentration and sugarbeet root yield for petiole samples collected 65 days after planting.

IMPACT OF CERCOSPORA LEAF SPOT DISEASE SEVERITY ON SUGARBEET ROOT STORAGE

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* (Crous et al., 2001), is the most damaging foliar disease of sugarbeet in North Dakota and Minnesota (Khan and Hakk, 2016). Historically, fungicides have been used to control disease symptoms. However, *C. beticola* has developed tolerance to several fungicides that are used against this disease, increasing the likelihood that disease symptoms will develop during production and that roots harvested from CLS-diseased plants will be incorporated into storage piles.

In Minnesota and North Dakota, sugarbeet roots are stored in ventilated or frozen piles for up to eight months. While other production diseases such as Aphanomyces root rot, Fusarium yellows, rhizomania, and rhizoctonia root and crown rot, are known to have a negative impact on storage (Campbell and Klotz, 2006; Campbell and Klotz, 2008; Klotz and Campbell, 2009; Campbell et al., 2011; Campbell et al., 2014), the effects of CLS on sugarbeet root storage properties are not known. It is suspected that roots harvested from CLS-diseased plants do not store as well as healthy roots. However, the effects of CLS on storage properties such as respiration rate, sucrose loss, losses in recoverable sugar, and the accumulation of invert sugars and other impurities that increase sucrose loss to molasses have not been determined.

Research was initiated in 2018 and continued into 2019 to determine the impact of different levels of CLS disease severity on sugarbeet root storage properties after short-term and long-term storage. Roots with varying levels of CLS disease severity were obtained from a field that was inoculated with *C. beticola* and contained plots that received variations in fungicide treatments. After field plots were rated for CLS severity, roots from plots with very low, low, moderate, and severe CLS symptoms were harvested and used for evaluating storage properties after 30, 90 and 120 days in storage.

MATERIALS AND METHODS

Plants with varying severities of CLS were produced in 2018 and 2019 in fields near Foxhome, MN. Plots were six-rows wide (11 ft wide by 30 ft long) with 22 inches between rows and 4.7-inch spacing within rows. In 2018, plots were planted with Hilleshög 9528 sugarbeet seed on 12 May. In 2019, plots were planted with Seedex Cruze on 14 May. Plants were produced using recommended agronomic practices (Khan, 2018) and were inoculated with 5 lb ac^{-1} dried *C. beticola*-infected leaves on 28 June and 12 July in 2018 and 2019, respectively. Varying severity of CLS symptoms were obtained using the fungicide treatments described in **Table 1**, with all fungicides used at their full rates and applied to the middle four rows of each plot.

A randomized complete block design with four replicates was used. CLS disease severity was rated using a 1 – 10 scale where 1 indicates an absence of disease symptoms and 10 indicates complete defoliation and leaf regrowth. The middle two rows of each plot were harvested on 27 September in 2018 and on 10 September in 2019. Roots were washed and roots within a plot were randomly assigned to 10 root samples which served as the experimental unit for the storage study. A 10-root sample from each plot was ground to brei after harvest for the determination of sucrose content, loss to molasses, invert sugar concentration, impurity concentration, and recoverable sugar per ton prior to storage. The remaining 10-root samples from each plot were stored at 5°C (41°F) and 95% humidity in a cold room. Respiration rates of 10-root samples were determined after 30 and 120 days in storage for roots produced in 2018 and after 30, 90, and 120 days for roots produced in 2019. Respiration was determined using a Licor infrared CO_2 analyzer (Campbell et al., 2011). Following respiration rate determinations, samples were ground into brei, and these brei samples were used for determining sucrose content, loss to molasses, invert sugar concentration, impurity concentrations (sodium, potassium, and amino-nitrogen), and recoverable sugar per ton.

Table 1: Fungicide treatments and application dates used to obtain plants with varying severity of Cercospora leaf spot symptoms.

Disease Severity	2018 Production Year		2019 Production Year	
	Fungicide Treatment	Application Date	Fungicide Treatment	Application Date
Lowest	Minerva Duo	07/05/18	Super Tin + Proline + NIS	07/22/19
	Super Tin + Topsin	07/18/18	Super Tin + Proline + NIS	08/01/19
	Proline + Badge SC + NIS	07/31/18	Super Tin + Proline + NIS	08/14/19
	Mankocide	08/16/18	Super Tin + Proline + NIS	08/28/19
	Super Tin + Manzate	08/31/18		
Low	Super Tin + Manzate + Topsin	07/18/18	Super Tin + Manzate Max + Topsin	07/22/19
	Super Tin + Manzate + Topsin	07/31/18	Super Tin + Manzate Max + Topsin	08/01/19
	Super Tin + Manzate + Topsin	08/16/18	Super Tin + Manzate Max + Topsin	08/14/19
	Super Tin + Manzate + Topsin	08/31/18	Super Tin + Manzate Max + Topsin	08/28/19
Moderate	Minerva Duo	07/05/18	Gem	07/22/19
	Super Tin + Topsin	07/18/18	Gem	08/01/19
	Proline + Badge SC + NIS	07/31/18	Gem	08/14/19
			Gem	08/28/19
Severe	untreated		untreated	

PROGRESS REPORT

2018-2019 Storage Study

At harvest, root yield and recoverable sugar per acre were significantly reduced in polots with moderate or severe CLS disease symptoms (**Table 2**). Sucrose concentration and recoverable sugar per ton at harvest were also reduced in roots harvested from plants with moderate and severe CLS symptoms (**Table 3**). Lower sucrose concentration and lower recoverable sugar per ton (RST) after 30 and 120 days in storage were also found in roots from plants with moderate and severe CLS symptoms (**Table 3**). The reductions in sucrose concentration and RST in stored roots, however, reflected the lower values for these traits at harvest and were not due to accelerated sucrose loss during storage. Disease severity had no significant effect on root respiration rate after 30 or 120 days in storage or invert sugar concentration at 120 days in storage (**Table 3**). However, a small increase in invert sugar concentration in roots from plants with moderate or severe disease symptoms was observed in roots stored for 30 days.

2019-2020 Storage Study

Like the 2018 field study, root yield and recoverable sugar per acre were reduced for plots with moderate and severe CLS symptoms (**Table 4**). Presently, only respiration rate determinations for roots stored for 30 and 90 days are available, as roots have yet to be stored for 120 days and sucrose concentration, invert sugar concentration, and impurity concentrations will be determined after all tissue samples are collected. For roots stored for 30 and 90 days, however, CLS disease severity had no effect on root respiration rate (**Table 5**).

PRELIMINARY CONCLUSIONS

Data presently available from the 2018-2019 storage study and the ongoing 2019-2020 storage study suggest that Cercospora leaf spot, at any severity level, has little to no effect on sugarbeet root storage properties. However, this conclusion should be considered preliminary until all data from the 2019-2020 storage study have been analyzed and an additional repetition of the experiment is conducted beginning in 2020.

ACKNOWLEDGEMENTS

The authors thank Peter Hakk and Joseph Thompson for technical assistance and the Sugarbeet Research & Education Board of MN & ND for partial financial support of this research. Mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer

Table 2: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 27 September 2018 from a field near Foxhome, MN. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4).

CLS severity class	Disease rating	Yield (tons acre^{-1})	Recoverable sugar (lbs acre^{-1})
lowest	3.0 c	30.7 ab	8738 ab
low	3.3 c	33.7 a	9395 a
moderate	6.0 b	27.0 bc	6800 bc
severe	9.8 a	23.3 c	5685 c

Table 3: Respiration rate, sucrose concentration, sucrose loss to molasses, recoverable sugar per ton, and invert sugar concentration at harvest and during storage for roots from plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 27 September 2018 from a field near Foxhome, MN and stored for up to 120 days at 5°C and 95% relative humidity. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4). DIS = days in storage.

CLS severity class	Disease rating	Respiration rate		Sucrose concentration			Sucrose loss to molasses			Recoverable sugar per ton			Invert sugar concentration		
		30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS
		- - (mg kg^{-1} h^{-1}) - -		- - - - - - - - - (%) - - - - - - - - - -			- - - - - - - - - - (%) - - - - - - - - - -			- - - - - - - (lbs ton^{-1}) - - - - - - -			- - - (g per 100 g sucrose) - - -		
lowest	3.0 c	2.48 a	2.42 a	16.0 a	15.8 a	15.7 a	1.72 a	1.50 a	1.70 a	285 a	286 a	279 a	1.28 a	0.60 c	3.51 a
low	3.3 c	2.71 a	2.89 a	15.7 a	15.7 a	15.2 a	1.79 a	1.65 a	1.52 a	278 ab	281 a	273 a	0.79 a	0.65 bc	2.10 a
moderate	6.0 b	2.41 a	2.73 a	14.1 b	13.6 b	13.7 b	1.58 a	1.57 a	1.47 a	251 bc	241 b	246 b	1.03 a	0.87 ab	4.42 a
severe	9.8 a	2.76 a	3.10 a	13.7 b	14.0 b	13.5 b	1.59 a	1.62 a	1.47 a	243 c	248 b	241 b	1.00 a	1.00 ab	4.59 a

Table 4: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 10 September 2019 from a field near Foxhome, MN. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4).

CLS severity class	Disease rating	Yield (tons acre^{-1})	Recoverable sugar (lbs acre^{-1})
lowest	3.0 c	31.7 a	8709 a
low	3.5 c	30.3 a	8171 a
moderate	5.8 b	25.9 b	6753 b
severe	8.8 a	21.5 c	5467 b

Table 5: Respiration rate after 30 and 90 days in storage for roots from plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 10 September 2019 from a field near Foxhome, MN and stored for 30 or 90 days at 5°C and 95% relative humidity. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4). DIS = days in storage.

CLS severity class	**Disease rating**	**Respiration rate (mg kg^{-1} h^{-1})**	
		30 DIS	**90 DIS**
lowest	3.0 c	2.18 a	3.66 a
low	3.5 c	2.55 a	3.55 a
moderate	5.8 b	2.72 a	3.39 a
severe	8.7 a	2.94 a	3.48 a

References

Campbell, L.G., Fugate, K.K., Niehaus, W.S. (2011). Fusarium yellows affects postharvest respiration rate and sucrose concentration in sugarbeet. J. Sugar Beet Res. 48:17-39.

Campbell, L.G., Klotz, K.L. (2006). Postharvest storage losses associated with *Aphanomyces* root rot in sugarbeet. J. Sugar Beet Res. 43:113-127.

Campbell, L.G., Klotz, K.L. (2008). Postharvest storage losses associated with rhizomania in sugar beet Plant Dis. 92:575-580.

Campbell, L.G., Windels, C.E., Fugate, K.K., Brantner, J.R. (2014). Postharvest losses associated with severity of rhizoctonia crown and root rot of sugarbeet at harvest. J. Sugar Beet Res. 51:31-51.

Crous, P.W., Kang, J.-C., Braun, U. (2001). A phylogenetic redefinition of anamorph genera in *Mycosphaerella* based on ITS rDNA sequence and morphology. Mycologia 93:1081-1101.

Khan, M., Ed. (2018). 2018 Sugarbeet Production Guide. Fargo, ND: North Dakota State Univ. Extension Ser., Publication A1698.

Khan, M.F.R., Hakk, P.C. (2016). Efficacy of fungicides for controlling Cercospora leaf spot on sugarbeet. 2015 Sugarbeet Res. Ext. Rep., Coop. Ext. Serv., North Dakota State Univ., 46:118-121.

Klotz, K.L., Campbell, L.G. (2009). Effects of Aphanomyces root rot on carbohydrate impurities and sucrose extractability in postharvest sugar beet. Plant Dis. 93:94-99.

ENTOMOLOGY

NOTES

TURNING POINT® SURVEY OF SUGARBEET INSECT PEST PROBLEMS AND MANAGEMENT PRACTICES IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2018

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Attendees of the 2019 Winter Sugarbeet Grower Seminars were asked about their 2018 insect pest problems and associated management practices in a live polling questionnaire by using a Turning Point® interactive personal response system. Initial questioning identified the county in which respondents produced the majority of their sugarbeet crop in 2018 (Tables 1, 2, 3, and 4). This report does not include data from the Willmar Seminar because that survey did not include questions on insect pest incidence or insect pest management practices.

Table 1. 2019 Fargo Grower Seminar – county in which sugarbeet was grown in 2018

County	Number of Responses	Percent of Responses
Becker	1	3
Cass	12	31
Clay	10	26
Norman[1]	12	32
Richland	2	5
Traill	1	3
Totals	38	100

[1]Includes Mahnomen County

[2]Includes Otter Tail County

Table 2. 2019 Grafton Grower Seminar – county in which sugarbeet was grown in 2018

County	Number of Responses	Percent of Responses
Grand Forks	3	8
Kittson	5	13
Marshall	2	5
Pembina	13	33
Walsh	14	36
Other	2	5
Totals	39	100

Table 3. 2019 Grand Forks Grower Seminar – county in which sugarbeet was grown in 2018

County	Number of Responses	Percent of Responses
Grand Forks	19	21
Mahnomen	1	1
Marshall	9	10
Pennington/Red Lake	1	1
Polk	45	51
Traill	2	2
Walsh	4	5
Other	8	9
Totals	89	100

Table 4. 2019 Wahpeton Grower Seminar – county in which sugarbeet was grown in 2018

County		Number of Responses	Percent of Responses
Clay		3	10
Grant		4	13
Richland		6	20
Traverse		1	3
Wilkin		16	53
	Totals	30	99

This report is based on an estimated 145,059 acres of sugarbeet grown in 2018 by 191 survey respondents that attended the 2019 Fargo, Grafton, Grand Forks, and Wahpeton Winter Sugarbeet Grower seminars (Table 5). The majority (39%) of respondents reported growing sugarbeet on between 400 and 799 acres during the 2018 production season. An additional 9% grew sugarbeet on between 300 and 399 acres, whereas 12% produced sugarbeet on 1,000 to 1,499 acres, and another 11% grew the crop on a reported range of over 1,500 acres in 2018. The remaining 20% of growers surveyed reported growing sugarbeet on up to 299 acres.

Table 5. Ranges of sugarbeet acreage operated by respondents in 2018

		Acres of sugarbeet									
Location	Number of Responses	<99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		-----% of responses-----									
Fargo	36	6	6	8	3	28	17	6	8	11	8
Grafton	42	5	14	0	10	33	14	17	5	2	0
Grand Forks	83	11	7	5	4	16	20	7	17	8	5
Wahpeton	30	7	3	0	30	20	10	7	13	7	3
Totals	191	8	8	4	9	22	17	9	12	7	4

From a total of 178 respondents at the Fargo, Grafton, Grand Forks, and Wahpeton seminars, 36% reported that the sugarbeet root maggot was their worst insect pest problem during the 2018 growing season (Table 6). That was a significant increase from 2017, for which only 27% of growers viewed the root maggot as their worst insect pest problem. The majority of respondents at both Grafton (57% of respondents) and Grand Forks (52% of respondents) identified the sugarbeet root maggot as their worst insect pest problem in 2018. Other significant insect pest problems reported included cutworms (13 and 7% of respondents at Fargo and Wahpeton, respectively), and wireworms (10, 5, 5, and 10% of respondents, respectively, at Fargo, Grafton, Grand Forks, and Wahpeton.

Table 6. Worst insect pest problem in sugarbeet in 2018

Location	Number of Responses	Springtails	Cutworms	Lygus bugs	Wireworms	Root maggot	White grubs	Grass-hoppers	None
		--			% of responses			--	
Fargo	31	3	13	0	10	3	0	0	71
Grafton	42	0	0	0	5	57	0	7	31
Grand Forks	75	9	3	0	5	52	0	1	29
Wahpeton	30	7	7	7	10	0	3	0	67
Totals	178	6	4	1	7	36	1	2	43

The majority (66%) of grower respondents, averaged across all four seminar locations, indicated that they planted seed treated with Poncho Beta insecticidal seed treatment in 2018, whereas NipsIt Inside- and Cruiser- treated seed were each only used by 3% of respondents (Table 7). Growers at the Fargo, Grafton, and Grand Forks grower seminars reported most of the seed treatment use for the production area in 2018. The highest use of Poncho Beta in 2018 was reported by seminar attendees at Fargo (79%), Grafton (77%), and Grand Forks (75%); whereas, the highest use of NipsIt Inside was reported by Grafton and Grand Forks attendees. A relatively large number (28%) of respondents at these events reported not using an insecticidal seed treatment. Wahpeton seminar attendees significantly influenced this figure, as 92% reported no seed treatment insecticide use in 2018.

Table 7. ***Seed treatment*** **insecticide use for sugarbeet insect pest management in 2018**

Location	Number of Responses	Poncho Beta	Cruiser	NipsIt Inside	None
		----------% of responses----------			
Fargo	33	79	0	0	21
Grafton	35	77	3	9	11
Grand Forks	76	75	5	4	16
Wahpeton	26	8	0	0	92
Totals	170	66	3	3	28

Planting-time granular insecticides were used in 2018 by an average of 32.5% of grower attendees of the Fargo, Grafton, Grand Forks, and Wahpeton seminars (Table 8). An overall average of 28% of growers at these meetings reported using Counter 20G at planting time, whereas only 2% of attendees reported applying Lorsban 15G for planting-time protection of their sugarbeet crop from insect pests. Grower-reported use of Counter 20G as a planting-time treatment by Fargo and Grand Forks seminar respondents was at 42 and 32%; whereas only 17 and 19% of growers at the Grafton and Wahpeton locations, respectively, reported using Counter 20G at planting to protect their sugarbeet crop. Overall, 68% of respondents across all four grower seminars reported that they did not use a granular insecticide at planting in 2018.

Table 8. ***Planting-time granular*** **insecticides used for insect pest management in sugarbeet during 2018**

Location	Number of Responses	Counter 20G	Lorsban 15G	Thimet 20G	Other	None
		----------% of responses----------				
Fargo	38	42	0	0	5	53
Grafton	42	17	5	0	0	78
Grand Forks	76	32	1	1	0	66
Wahpeton	31	19	0	0	3	77
Totals	187	28	2	0.5	2	68

Averaged across all seminar locations, the majority (28%) of planting-time granular insecticide use in 2018 involved Counter 20G (Table 9). The most commonly used application rate of Counter in 2018 was the moderate rate of 7.5 lb product/ac, which was used by 14% of all grower seminar attendees. An additional 7% used Counter at its highest labeled application rate (9 lb/ac), and another 7% applied it at the low labeled rate of 5.25 lb/ac.

The majority (52%) of Fargo respondents reported no use of Counter 20G, but 24% reported using it at the low (5.25 lb product/ac) rate, and 18% used the moderate (7.5-lb) rate. The majority of growers surveyed at Grafton and Wahpeton (81% at both locations) reported no use of a granular insecticide at planting. Similarly, 70% of the Grand Forks attendees reported that they did not use a planting-time granular insecticide. However, a total of 28% of Grand Forks attendees used Counter 20G, and most (19%) reported using it at the 7.5-lb application rate. Similarly, 19% of Wahpeton attendees reported using Counter 20G for their planting-time-applied protection from insect pests; however, they used the 7.5-lb rate slightly more than the high and low labeled rates. A small number (2%) of growers at the Grafton seminar reported using Lorsban 15G (or a generic granular chlorpyrifos product) for planting-time insecticide protection, and all appled it at the highest labeled rate of 13.4 lb of product per acre.

Table 9. Application rates of *planting-time granular* insecticides used for sugarbeet insect pest managemen in 2018

Location	Number of Responses	Counter 20G			Lorsban 15G			Other	None
		9 lb	7.5 lb	5.25 lb	13.4 lb	10 lb	6.7 lb		
		---------------------------------------% of responses---------------------------------------							
Fargo	33	6	18	24	0	0	0	0	52
Grafton	41	10	5	2	2	0	0	0	81
Grand Forks	73	8	19	1	0	0	0	1	70
Wahpeton	31	3	10	6	0	0	0	0	81
Totals	178	7	14	7	0.5	0	0	0.5	71

For postemergence root maggot management in 2018, 47% of all grower seminar attendees reported using some form of insecticide. The majority (30%) of which chose Lorsban or a similar chlorpyrifos-containing sprayable liquid insecticide, whereas, Mustang Maxx and Thimet were both only used by 5% of respondents. An additional 4% reported using Lorsban 15G for this purpose.

At the Fargo grower seminar, 13% of respondents reported that they used a sprayable liquid formulation of Lorsban, and 11% of respondents applied Mustang Maxx for postemergence root maggot management in 2018. In contrast, 43 and 42% of the Grafton and Grand Forks seminar attendees, respectively, reported using sprayable liquid Lorsban for root maggot control. Mustang Maxx was reported as being used by 15% of the Wahpeton attendees for this purpose. Grafton seminar attendees indicated the highest incidence of using Thimet 20G for postemergence root maggot control (11% of respondents), whereas just 5% of Grand Forks seminar attendees used Thimet. Lorsban 15G was reported as being used for this purpose by just 7% of respondents at both Grafton and Grand Forks. An additional 2% of Grafton respondents reported using Counter 20G as a postemergence treatment for root maggot control.

An average of 53% of survey respondents across all locations indicated that they did not apply a postemergence insecticide to manage the sugarbeet root maggot in 2018. The majority of those respondents were attendees of the Fargo and Wahpeton locations, where a respective 76 and 85% of respondents reported no use of a postemergence insecticide for root maggot control.

Table 10. *Postemergence* insecticide use for *sugarbeet root maggot* management in 2018

Location	Number of Responses	Lorsban (4E, Advanced, or a generic)	Mustang Maxx	Asana	Other liquid	Counter 20G	Lorsban 15G	Thimet 20G	None
		--% of responses--							
Fargo	37	13	11	0	0	0	0	0	76
Grafton	44	43	2	0	5	2	7	11	30
Grand Forks	74	42	0	1	0	0	7	5	45
Wahpeton	27	0	15	0	0	0	0	0	85
Totals	182	30	5	0.5	1	0.5	4	5	53

Overall satisfaction with insecticide applications made for root maggot management was rated as good to excellent by 85% of respondents when averaged across the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations (Table 11). That was a reduction from 86% of attendees of all seminars rating their root maggot control performance as good to excellent during the previous growing season (2017). At the Fargo location, 90% of respondents rated their satisfaction with root maggot control tools as being good to excellent. Similarly, most (92%) of the respondents rated their satisfaction with root maggot management practices as being good to excellent at the Grafton seminar location. Although the majority (78%) of Grand Forks seminar attendees also rated their insecticide performance as good to excellent, that figure was down from 90% during the previous survey year (2017 growing season). Although 100% of respondents at the Wahpeton seminar rated their satisfaction with performance of root maggot management practices as good to excellent, that figure was only based on six respondents.

Table 11. *Satisfaction* with insecticide treatments for sugarbeet root maggot management in 2018

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		-----% of responses-----				
Fargo	20	70	20	0	0	10
Grafton	37	41	51	8	0	0
Grand Forks	61	29	49	15	0	7
Wahpeton	6	67	33	0	0	0
Totals	124	41	44	10	0	5

A total of 181 growers responded to the question pertaining to which insecticide they used for springtail management in 2018 (Table 12). Averaged across all locations, Poncho Beta was relied on by 25% of respondents for springtail control, which was more than any other chemical tool used to manage springtails in 2018. However, 46% of all growers surveyed at the four seminar locations reported not using an insecticide for springtail control. Counter 20G was used by 17% of all survey respondents, and Mustang Maxx was used by 8% of the attendees across all four seminar locations.

At the Fargo seminar, Counter 20G and Poncho Beta were used by 32% and 24% of respondents, respectively, with only 3% of growers reporting that they used Mustang Maxx for springtail control and 41% reporting that they did not use any insecticide for this purpose in 2018. Insecticide use for springtail management by Grafton seminar attendees was split between Mustang Maxx, Poncho Beta, and Counter 20G (18, 12, and 10%, respectively). An additional 2% of growers at the Grafton seminar reported using NipsIt Inside seed treatment for their springtail control, and 58% of respondents at that location indicated no insecticide use for this purpose in 2018. The majority (43%) of the 76 respondents at Grand Forks reported using Poncho Beta for springtail control, and an additional 18% used Counter 20G for this purpose. Only 4% of Grand Forks attendees reported using Cruiser seed treatment for springtail management, and 30% of them reported no insecticide use for springtail management. The majority (74%) of attendees at the Wahpeton seminar indicated that they did not use an insecticide to control springtails; however, 16% of respondents there reported using Mustang Maxx, and a small number (7%) of attendees relied on a planting-time application of Counter 20G for springtail control. NipsIt Inside insecticidal seed treatment was used by 3% of Wahpeton attendees for protection against springtail infestations.

Table 12. Insecticide use for *springtail* management in 2018

Location	Number of Responses	Cruiser	NipsIt Inside	Poncho Beta	Mustang Maxx	Counter 20G	Lorsban 15G	Other	None
		--% of responses--							
Fargo	34	0	0	24	3	32	0	0	41
Grafton	40	0	2	12	18	10	0	0	58
Grand Forks	76	4	0	43	1	18	3	0	30
Wahpeton	31	0	3	0	16	7	0	0	74
Totals	181	2	1	25	8	17	1	0	46

As presented in Table 13, 74% of grower respondents across all four seminar locations rated their insecticide performance for springtail management as good to excellent, and only 2% rated insecticide performance as poor. Satisfaction among growers was mostly similar across locations, with ratings of good to excellent by 77, 85, and 86% of respondents at Fargo, Grafton, and Wahpeton, respectively. Exceptions included slightly less satisfaction (68% good to excellent) with Grand Forks respondents, and 14% of Wahpeton respondents rating performance as poor.

Table 13. *Satisfaction* with insecticide treatments for springtail management in 2018

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		---% of responses---				
Fargo	22	36	41	5	0	18
Grafton	13	39	46	0	0	15
Grand Forks	54	22	46	9	2	20
Wahpeton	7	43	43	0	14	0
Totals	96	29	45	6	2	18

Of the 173 growers surveyed across all seminar locations, 86% reported no use of an insecticide for Lygus bug management in 2018 (Table 14). This was common across all locations, with percentages of growers reporting no insecticide use for this purpose ranging from 83% of Wahpeton attendees to 88% of those at Fargo. At the Grafton location, 13% of respondents reported using Lorsban or a generic version of chlorpyrifos for Lygus control in their sugarbeet crop. Similarly, 10% of grower respondents at Wahpeton reported using Mustang Maxx to control this pest. Lorsban (or a generic equivalent) was used by 8% of Grand forks attendees for Lygus bug management.

Table 14. Insecticide use for *Lygus bug* management in 2018

Location	Number of Responses	Asana	Lannate	Lorsban (4E, Advanced, or generic)	Movento	Mustang Maxx	Other	None
		----------	----------	----------	% of responses	----------	----------	----------
Fargo	33	0	0	3	3	3	3	88
Grafton	39	0	0	13	0	0	0	87
Grand Forks	72	1	0	8	0	0	4	86
Wahpeton	29	3	0	3	0	10	0	83
Totals	173	1	0	8	0.5	2	2	86

Although a relatively small number of growers (i.e., 24 across all locations) responded to the question regarding satisfaction with insecticide performance for Lygus bug control, 67% rated it as good to excellent (Table 15). Satisfaction levels of good to excellent ranged from 50% at the Grand Forks seminar location to 100% at Grafton, although it should be noted that only four respondents answered this question at the Grafton seminar. No respondents rated their insecticide performance as poor at any of the locations; however, 33 and 50% of respective attendees at Fargo and Grand Forks responded as being unsure of the quality of their insecticide performance.

Table 15. *Satisfaction* with insecticide treatments for Lygus bug management in 2018

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		----------	----------	% of responses	----------	----------
Fargo	3	0	67	0	0	33
Grafton	4	25	75	0	0	0
Grand Forks	10	40	10	0	0	50
Wahpeton	7	57	14	14	0	14
Totals	24	38	29	4	0	29

The majority (81%) of respondents, averaged across all grower seminar locations, reported that they applied their postemergence liquid insecticides in a total spray output volume of between six and 10 gallons per acre (GPA). At individual locations, the percentage producers that reported using this spray output volume ranged from 60% at Wahpeton to 89% at Grafton. Responses to this question at Wahpeton should be considered with discretion, as only five individuals provided input on it at that seminar location. At Fargo and Grand Forks, 17 and 14% of respondents, respectively, reported applying postemergence insecticide sprays in a volume of 11 to 15 GPA. Small numbers (6 to 8%) of attendees at the Fargo and Grand Forks grower seminars responded as having used an output volume of one to six gallons per acre to deliver their postemergence liquid insecticide. Using such a low output volume for a ground-based foliar application would be quite rare and, most likely, ineffective for insect control. It is possible that some respondents misread this question, and responded with the output volume of treatments made on their fields by aircraft. However, that is only speculated, and cannot be concluded with a reasonable level of certainty. A small number (4%) of respondents at Grafton also reported applying their postemergence insecticides at the higher output volume range of 16 to 20 GPA.

Table 16. Spray volume output used for ground-applied postemergence insecticide applications in 2018

Location	Number of Responses	1–5 GPA	6–10 GPA	11–15 GPA	16–20 GPA	> 20 GPA
		------------------------------------	------------------------------------	% of responses	------------------------------------	------------------------------------
Fargo	12	8	75	17	0	0
Grafton	28	0	89	7	4	0
Grand Forks	35	6	80	14	0	0
Wahpeton	5	20	60	0	0	20
Totals	80	5	81	11	1	1

Overall, 73% of all respondents at the 2019 Winter Sugarbeet Grower Seminars (all locations combined) reported that their insecticide use in 2018 was not different from what it had been during the previous five years (Table 17). At the Fargo Growers Seminar, 8% of respondents indicated that their insecticide use in sugarbeet had decreased, and 78% of respondents at that location reported no change in insecticide use in comparison to the past five years. However, 8% of grower respondents at both Grafton and Wahpeton, as well as 13% of Grand Forks attendees, indicated that their insecticide use had increased when compared to the previous five years. This finding was probably due to sugarbeet root maggot population increases in 2018 in areas that typically experience lower root maggot infestations. At the Wahpeton seminar location, 46% of attendees reported that they did not use an insecticide on their sugarbeet crop in 2018.

Table 17. Insecticide use in sugarbeet during 2018 compared to the previous 5 years

Location	Number of Responses	Increased	Decreased	No Change	No Insecticide Use
		--------------------------% of responses	--------------------------		
Fargo	36	6	8	78	8
Grafton	38	8	5	84	3
Grand Forks	75	13	8	77	1
Wahpeton	26	8	8	38	46
Totals	175	10	7	73	10

Averaged across all 2019 grower seminar locations, 77% of respondents indicated that they used some form of online or cellular-enabled information source for information regarding sugarbeet insect management during the 2018 growing season (Table 18). The most commonly used online/electronic decision-making tools used by attendees for pest management in 2018, as averaged across locations, included cellular text alerts (28%), the NDSU Crop & Pest report (16%), and the NDSU Entomology Department's online posting of sugarbeet root maggot fly counts (12%).

At the Fargo seminar, about 73% of respondents indicated using some form of online information, with most use involving the NDSU Crop & Pest Report (27%) and cellular text-alert system (20%). The majority (30%) of respondents at Grafton reported using the text-alert system, and 14% of them used the Crop & Pest Report weekly newsletter, and 11% of Grafton attendees also reported using NDSU's online posting of root maggot fly counts and the NDSU Root Maggot Model on the North Dakota Agricultural Weather Network (NDAWN) website for guidance with management decisions. Attendees of the Grand Forks seminar location reported substantially greater use of the cellular text-alert system (39% of respondents) and the online posting of NDSU's root maggot fly counts (20%) than at any other seminar location. Ten percent of Grand Forks attendees also reported using the NDSU Crop & Pest Report for information and their pest management decision-making activities in 2018. The majority of Wahpeton respondents indicated no use of online/electronic tools for acquiring insect pest management information; however, 18% of them responded as getting information from the NDSU Crop & Pest Report.

Table 18. Use of online decision-making tools for sugarbeet insect management in 2018

Location	Number of Responses	Cellular text alerts	Maggot Mobile app	NDSU Crop&Pest Report	Root Maggot Fly Count Website	Root Maggot Model (NDAWN)	Sugarbeet Production Guide	Other	None
		---% of responses---							
Fargo	45	20	2	27	7	4	7	7	27
Grafton	56	30	7	14	11	11	0	11	16
Grand Forks	96	39	3	10	20	2	4	8	14
Wahpeton	28	4	0	18	0	0	7	7	64
Totals	225	28	4	16	12	4	4	8	23

SUGARBEET ROOT MAGGOT FLY MONITORING IN THE RED RIVER VALLEY IN 2019

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In a cooperative effort between the NDSU Department of Entomology and American Crystal Sugar Company, sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), fly activity was monitored at 119 grower field sites throughout the Red River Valley during the 2019 growing season.
For the second consecutive year, root maggot fly activity was at exceptionally high levels throughout much of the Valley. Fly activity levels in 2019 were the second-highest recorded in the past 13 years for the growing area (Figure 1). This suggests that control efforts between 2017 and 2019 were unsuccessful in reducing overall population levels for many producers.

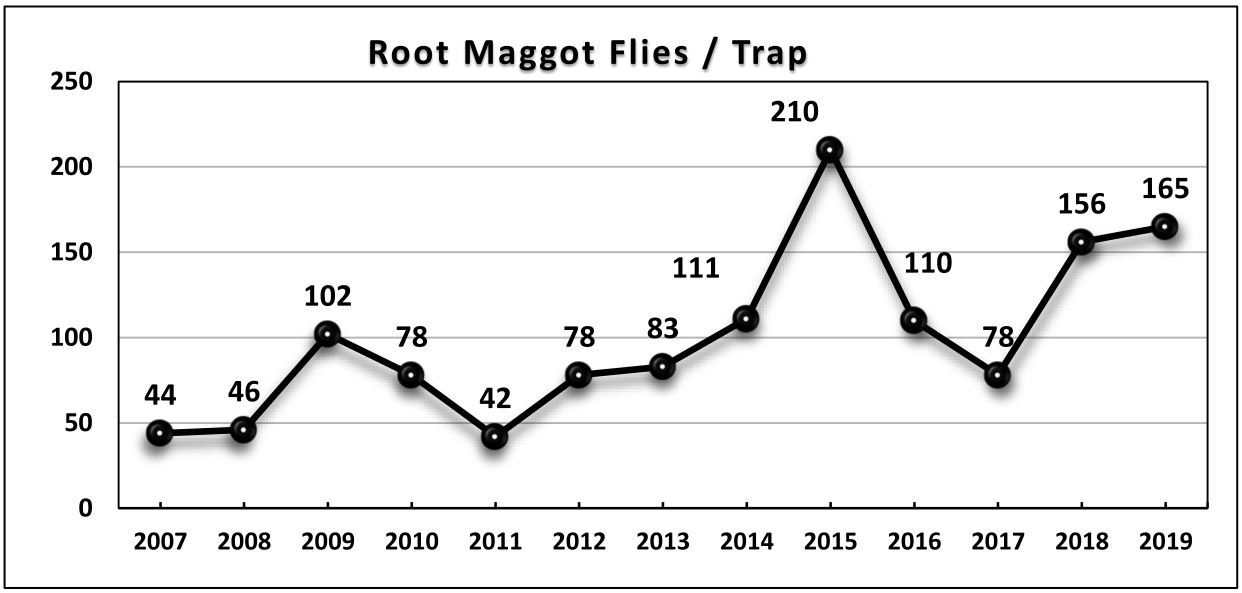

Figure 1. Yearly averages of sugarbeet root maggot flies captured on sticky-stake traps (Blickenstaff and Peckenpaugh, 1976) in the Red River Valley from 2007 to 2019.

The highest levels of SBRM fly activity observed in 2019 occurred near Auburn, Bathgate, Buxton, Cavalier, Crystal, Glasston, Grand Forks, Hamilton, Merrifield, Reynolds, St. Thomas, Thompson, and Walhalla, ND, as well as near Argyle, Crookston, Donaldson, East Grand Forks, Eldred, Fisher, and Stephen, MN. Moderately high levels of activity were recorded near Drayton, Forest River, Merrifield, Nash, and Reynolds, ND, and near Ada and Warren, MN. Fly activity in most of the southern portion of the Valley remained at relatively low or undetectable levels throughout the growing season, which has been the case in that part of the growing area for several years.

Figure 2 presents SBRM fly monitoring results from three representative sites (i.e., St. Thomas and Thompson, ND, and East Grand Forks, MN) during the 2019 growing season. Fly emergence began unusually early in northern parts of the Valley, with the first occurrences of high fly activity being observed during the first week of June in the areas surrounding St. Thomas and East Grand Forks. That is about one week ahead of the historical average peak fly activity date for these growing areas. The main peaks in activity for much of the remaining monitoring sites occurred on or within one or two days of June 17. The occurrence of two peaks in one growing season is somewhat rare. It is hoped that the early emergence observed during the springs of both 2018 and 2019 were just anomalies resulting from unseasonably warm early spring temperatures, and not the onset of a developing new “normal” for SBRM fly activity in the region.

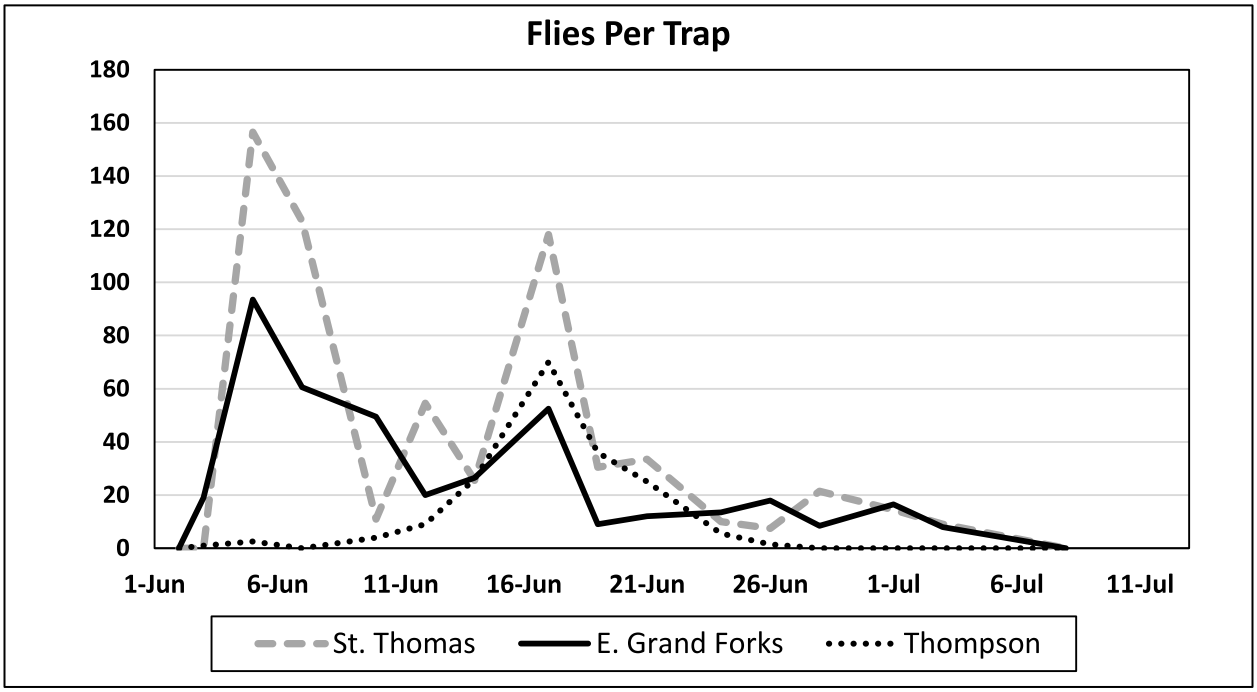

Fig. 2. Sugarbeet root maggot flies captured on sticky-stake traps at selected sites in the Red River Valley.

In late-summer, after the larval feeding period had ended, 48 of the fly monitoring sites were rated for sugarbeet root maggot feeding injury in accordance with the 0-9 scale of Campbell et al. (2000) to assess whether fly outbreaks and larval infestations were managed effectively. The resulting data is subsequently overlaid with corresponding fly count data to develop a root maggot risk forecast map for the subsequent growing season (the forecast for next year is presented in the report immediately following this one).

Root maggot feeding injury, averaged across all RRV fields that exceeded the generalized economic threshold (43 cumulative flies per trap), was 2.06 on the 0 to 9 scale. That amounted to a 117% increase over the same figure recorded for 2017. A list of RRV locations where the highest average root injury ratings were observed is presented in Table 1. Cumulative SBRM fly activity in those fields ranged from 50 flies/trap near Crookston, MN to 670 flies/trap near Crystal, ND.

The comparatively high root injury ratings observed at the locations listed in Table 1 provide more evidence that control efforts in those areas were not as successful as growers may have hoped. As indicated in the table, root injury ratings in fields near Argyle, Auburn, Cavalier, Crystal, Donaldson, East Grand Forks, Glasston, St. Thomas, and Walhalla, averaged between 3.28 and 5.74. Also, root injury levels in four additional fields in the vicinity of Cavalier, Crookston, and Thompson averaged at or above 2.5. This is alarming because it is somewhat rare for root maggot feeding injury ratings in grower-managed fields to exceed 3.0.

As such, the risk of damaging SBRM infestations in those areas for the 2020 growing season will be high. Careful monitoring of fly activity in moderate- and high-risk areas (see Forecast Map [Fig. 1] in subsequent report) will be critical to preventing economic loss in 2020. Vigilant monitoring and effective SBRM management on an individual-field basis by sugarbeet producers could also help prevent significant population increases from one year to another, because even moderate levels of root maggot survival in one year can be sufficient to result in economically damaging infestations in the subsequent growing season.

Table 1. Sugarbeet root maggot feeding injury in several Red River Valley sugarbeet fields where injury exceeded 2.5, 2019				
Nearest City	**Township**	**State**	**Flies/stake**	**Average Root Injury Rating[a]**
E. Grand Forks	Sullivan	ND	145	5.74
Auburn	Martin	ND	130	4.74
Argyle	Alma	MN	651	4.54
Glasston	Lodema	ND	236	4.33
Walhalla	Advance	ND	161	4.10
St. Thomas	South Cavalier	ND	529	3.92
St. Thomas	South St. Thomas	ND	368	3.67
Cavalier	North Cavalier	ND	191	3.59
Crystal	Elora	ND	158	3.56
St Thomas	South St. Thomas	ND	615	3.51
Donaldson	Spring Brook	MN	154	3.31
St. Thomas	North St. Thomas	ND	112	3.31
Crystal	Elora	ND	670	3.28
Crookston	Crookston	MN	433	2.82
Cavalier	North Cavalier	ND	216	2.72
Thompson	Americus	ND	181	2.62
Crookston	Fairfax	MN	50	2.56

[a]Sugarbeet root maggot feeding injury rating based on the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

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References Cited:

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

Blickenstaff, C.C., and R.E. Peckenpaugh. 1976. Sticky-Stake traps for monitoring fly populations of the sugarbeet root maggot and predicting maggot population and damage ratings. J. Am. Soc. Sugar Beet Technol. 19: 112–117.

SUGARBEET ROOT MAGGOT FORECAST FOR THE 2020 GROWING SEASON

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The 2020 sugarbeet root maggot (SBRM) forecast map for the Red River Valley (RRV) is shown in the figure below. The 2019 growing season marked the third consecutive year of significant increases in fly activity and SBRM feeding injury at several RRV locations. This suggest that SBRM infestations in 2020 will generally be higher than in previous years. Areas at highest risk of damaging SBRM infestations include rural Auburn, Bathgate, Cavalier, Crystal, Glasston, Grand Forks, Merrifield, St. Thomas, Thompson, and Walhalla, ND, as well as Argyle, Crookston, Donaldson, East Grand Forks, Eldred, and Stephen, MN. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Drayton, Buxton, Forest River, Hamilton, Nash, Oakwood, and Reynolds, ND, and Ada, Crookston, Eldred, and Fisher, MN. The remainder of the area is at lower risk. Proximity to previous-year beet fields where SBRM populations were high and/or control was unsatisfactory can increase risk. Sugarbeet fields near those where high fly activity occurred in 2019 should be closely monitored in 2020. Growers in high-risk areas should use an aggressive form of at-plant insecticide treatment (i.e., granular insecticide) and expect the need for a postemergence rescue insecticide (i.e., banded granules or peak-fly spray). Those in moderate-risk areas using insecticidal seed treatments for at-plant protection should monitor fly activity levels closely in their area, and be ready to apply additive protection if justified. Any grower in an area with a history of SBRM problems should pay close attention to fly activity levels in late-May through June to decide if postemergence treatment is needed. NDSU Entomology will continue to inform growers regarding SBRM activity levels and hot spots each year through radio reports, the NDSU "Crop & Pest Report", and notification of sugar cooperative agricultural staff when appropriate. Root maggot fly counts for the current growing season and those from previous years can be viewed at: http://www.ndsu.edu/entomology/people/faculty/boetel/flycounts/.

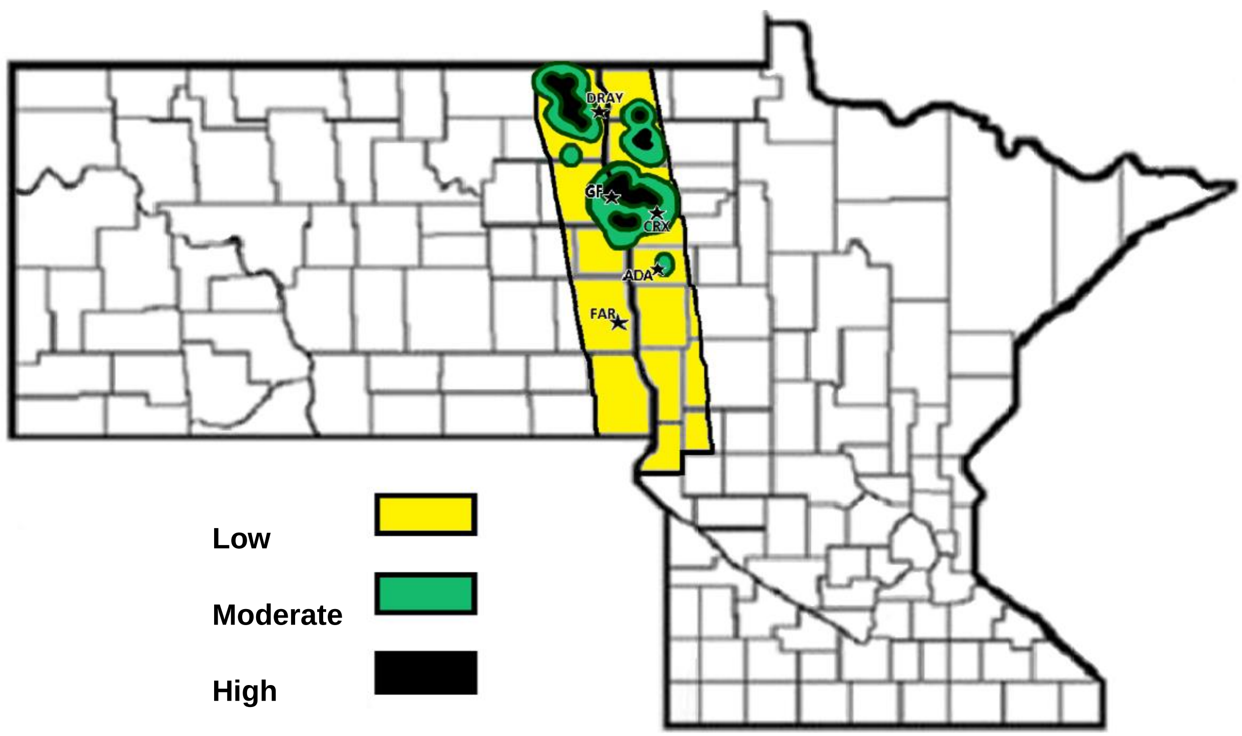

Fig. 1. Anticipated risk of SBRM fly activity and damaging larval infestations in the Red River Valley.

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SUGARBEET ROOT MAGGOT CONTROL BY USING SINGLE-, DUAL-, AND TRIPLE-COMPONENT INSECTICIDE REGIMES

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INTRODUCTION

Severe infestations of the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), occur on a frequent basis in central and northern portions of the Red River Valley (RRV) of North Dakota and Minnesota. Published research has demonstrated that this pest is capable of causing more than 45% yield losses in the absence of effective control measures (Boetel et al. 2010). High population levels of this pest typically require aggressive management programs to ensure adequate protection of the sugarbeet crop. Control programs in areas at high risk of economic loss from this pest usually consist of planting-time protection, in the form of a granular, liquid, or seed treatment insecticide, followed by an additive postemergence insecticide application (i.e., either a granular or sprayable liquid product) when the SBRM infestation warrants it. Broadcast applications of sprayable liquid insecticides, applied on an as-needed, rescue basis, are the most commonly used postemergence tools for SBRM control in the RRV. An advantage of postemergence sprays is that growers can use a "wait and see" approach, and make informed decisions on whether rescue insecticide treatments are needed based on current fly activity levels in their fields. This research was carried out to determine the most effective combinations of planting-time and postemergence liquid insecticide applications to optimize sugarbeet root maggot management methodology.

This project involved two experiments. The objectives of Study I were to: 1) compare Counter 20G granular insecticide with Poncho Beta seed treatment for at-plant SBRM control; 2) assess the efficacy of combining Poncho Beta with Counter 20G at planting time for a one-pass SBRM control system; 3) determine the impacts of additive postemergence applications of Thimet 20G to plots initially treated with either Counter 20G or Poncho Beta seed treatment for SBRM control; 4) measure the performance of Counter 20G as a postemergence control option; and 5) determine if SBRM control can be maximized by employing a three-component (i.e., seed treatment insecticide + at-plant or postemergence granular insecticide + postemergence liquid spray) management program.

The objectives of Study II were to: 1) measure the impacts of Poncho Beta seed treatment and Counter 20G (at differing application rates) on root maggot control in dual-insecticide programs that include postemergence broadcast spray applications of Lorsban Advanced; and 2) assess the effect of application rate on performance of Lorsban Advanced as the postemergence component of dual-insecticide programs for sugarbeet root maggot control.

MATERIALS AND METHODS

Both of these experiments were conducted on a commercial sugarbeet field site near St. Thomas (Pembina County), ND during the 2019 growing season. Betaseed 8524 glyphosate-resistant seed was used for all entries in both experiments, and a professional seed preparation company (Germains Seed Technology, Fargo, ND) applied Poncho Beta insecticide to seed for all entries that included an insecticidal seed treatment in these trials. Study I was planted on 15 May, and Study II was planted on 14 May, 2019. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. No insecticide was applied to the outer "guard" rows (i.e., rows one and six) of each plot, as those rows served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free throughout the growing season by using tillage operations. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticide applications</u>: Counter 20G was applied in both trials by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications.

Postemergence insecticide applications: Postemergence insecticides in Study I consisted of two granular materials (i.e., Counter 20G and Thimet 20G) and one sprayable liquid insecticide product (i.e., Lorsban Advanced). Postemergence band-applied (Post B) granules were applied on 14 June (i.e., 3 days before peak SBRM fly activity). Banded placement of postemergence granules was achieved by using Kinze™ row banders that were attached to a tractor-mounted tool bar and adjusted to a height to deliver the insecticides in 4-inch bands. Similar to at-plant insecticide applications, postemergence granular output rates were also regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar. All postemergence granular applications were incorporated by using two pairs of rotary tines that straddled each row on the tool bar. A paired set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone of each row unit. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules as the unit passed through each plot.

The postemergence spray applications of Lorsban Advanced in both Study I and Study II were broadcast-applied on 17 June (i.e., at peak SBRM fly activity). Sprays were applied from a tractor-mounted CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ 11001VS nozzles.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed for these experiments on 29 July (Study I) and 31 July (Study II). Rating procedures consisted of randomly collecting ten sugarbeet roots (five from each of the outer two treated rows) per plot, hand-washing them in a bucket of water, and scoring each in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots for both studies were harvested on 18 September. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

RESULTS AND DISCUSSION

Study I. Sugarbeet root maggot feeding injury rating results for Study I are presented in Table 1. The level of root injury that occurred in the untreated check plots (mean = 6.18 on the 0 to 9 scale of Campbell et al. [2000]) suggested that a moderately high infestation of SBRM larvae was present for the experiment. This level of pressure was slightly lower than expected, which was most likely due to the significant amount of rainfall (3.34") that occurred during the two-week period (i.e., June 7-21) that immediately surrounded peak SBRM fly activity in the field (see Appendix A at the end of the Entomology section of this publication). This likely contributed to substantial variability, in both insect pressure and yield, among plots and within replicates. As a result, there were relatively few significant differences between treatments.

All insecticide-protected plots in Study I sustained significantly lower levels of SBRM feeding injury than the untreated check, regardless of whether involving a seed treatment, a single at-plant granular insecticide application, or a multiple-application insecticide combination was used for SBRM control. General performance patterns demonstrated that single-component control programs are not sufficient to protect the crop from moderately high pressure such as that which existed for this trial.

The greatest root protection (i.e., lowest overall root injury) in Study I occurred in plots treated at planting with Counter 20G at its high (8.9 lb product/ac) rate plus a postemergence application of Thimet 20G at its high rate (7 lb product per acre). Other entries that provided excellent root protection (i.e., prevented SBRM feeding injury from exceeding 3.0 on the 0 to 9 scale) included the following:

1) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly);

2) Counter 20G (7.5 lb/ac, banded at planting) + Thimet (7 lb/ac, 3d before peak fly);
3) Counter banded at planting (8.9 lb/ac, banded at planting); and
4) Poncho Beta + Thimet 20G (7 lb/ac, 3d before peak fly) + Lorsban Advanced (1 pt/ac, peak fly).

Table 1. *Larval feeding injury* in an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence insecticides, St. Thomas, ND, 2019 (Study I)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Thimet 20G	B 3 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.20 d
Poncho Beta + Counter 20G + Lorsban Advanced	Seed B Peak fly Broadcast	 8.9 lb 1 pt	68 g a.i./ unit seed 1.8 0.5	2.23 d
Counter 20G + Thimet 20G	B 3 d Pre-peak Post B	7.5 lb 7 lb	1.5 1.4	2.23 d
Counter 20G	B	8.9 lb	1.8	2.60 cd
Poncho Beta + Thimet 20G + Lorsban Advanced	Seed 3 d Pre-peak Post B Peak fly Broadcast	 7 lb 1 pt	68 g a.i./ unit seed 1.4 0.5	2.73 cd
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	3.05 cd
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	3.20 cd
Poncho Beta + Thimet 20G	Seed 3 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	3.25 cd
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	3.33 cd
Counter 20G	B	7.5 lb	1.5	3.63 bc
Poncho Beta	Seed		68 g a.i./ unit seed	3.70 bc
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	4.50 b
Counter 20G	B	5.25 lb	1.05	4.68 b
Check	---	----	---	6.18 a
LSD (0.05)				1.161

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

Although there were relatively few significant differences among treatments in this trial with respect to SBRM feeding injury, positive application rate responses (i.e., higher rates performing numerically better than lower rates) were apparent when Counter was applied as a single-component treatment and when it was part of an integrated program. Additionally, applying Lorsban Advanced to establish a triple-component control program provided numerical improvements in root protection over corresponding single- and dual-component programs in this trial.

Yield data from Study I are presented in Table 2. All insecticide treatments in this experiment, except the single at-plant application of Counter 20G when applied at its lowest labeled rate (5.25 lb product/ac), resulted in statistically significant increases in recoverable sucrose yield when compared to the untreated check. As observed in the SBRM feeding injury data for Study I, trends suggested better performance with dual- and triple-component insecticide programs.

As observed in root injury rating results, the top-performing entry in Study I, with regard to recoverable sucrose yield and gross economic return, involved a planting-time application of Counter 20G at its high (8.9 lb product/ac) rate plus a postemergence application of Thimet 20G at its high rate (7 lb product per acre). That entry generated a gross revenue of $1,013/ac, which was $309/ac greater revenue than the untreated check plots and $77 more revenue than plots protected solely by the planting-time application of Counter at 8.9 lb/ac. The combination of Counter 20G at 8.9 lb/ac plus a postemergence application of Thimet 20G at 7.5 lb product per acre was statistically superior in relation to recoverable sucrose yield to the following treatments: 1) Poncho Beta + Counter 20G applied at postemergence at 5.25 lb/ac; 2) Poncho Beta + postemergence Thimet 20G at 7 lb/ac; 3) Poncho Beta alone; and 4) single applications of Counter at either its moderate (7.5-lb) or low (5.25-lb) labeled rate.

The following entries in Study I provided excellent gross economic returns, and were not statistically outperformed in relation to sucrose yield by the aforementioned top-performing treatment (Counter 20G at planting [8.9 lb/ac] + Thimet 20G [3d before peak fly, 7 lb/ac]):

1) Poncho Beta + Thimet 20G (7 lb/ac, 3d before peak fly) + Lorsban Advanced (1 pt/ac, peak fly);
2) Counter 20G (7.5 lb/ac, banded at planting) + Thimet (7 lb/ac, 3d before peak fly);
3) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly);
4) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting);
5) Poncho Beta + postemergence Counter 20G (8.9 lb/ac, 3d before peak fly);
6) Counter 20G (8.9 lb/ac, banded at planting); and
7) Poncho Beta + Counter 20G (5.25 lb/ac, banded at planting).

Although numerically lower than the gross economic return generated by the aforementioned top-yielding treatment, these control programs still generated between $130 and $283/ac more gross revenue than that recorded for the untreated check plots. These revenue increases would have easily paid for the product and application costs associated with their use, and also would have provided excellent net returns in revenue per acre for a producer.

Table 2. *Yield parameters* from an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence insecticides, St. Thomas, ND, 2019 (Study I)

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G +	B	8.9 lb	1.8	9915 a	33.3 a	16.53 a	1,013
Thimet 20G	3 d Pre-peak Post B	7 lb	1.4				
Poncho Beta +	Seed		68 g a.i./ unit seed	9573 ab	32.0 abc	16.60 a	987
Thimet 20G +	3 d Pre-peak Post B	7 lb	1.4				
Lorsban Advanced	Peak fly Broadcast	1 pt	0.5				
Counter 20G +	B	7.5 lb	1.5	9556 abc	33.8 a	15.75 ab	880
Thimet 20G	3 d Pre-peak Post B	7 lb	1.4				
Poncho Beta +	Seed		68 g a.i./ unit seed	9468 abc	32.6 ab	16.10 ab	922
Counter 20G +	B	8.9 lb	1.8				
Lorsban Advanced	Peak fly Broadcast	1 pt	0.5				
Poncho Beta +	Seed		68 g a.i./ unit seed	9352 a-d	32.5 ab	16.03 ab	894

Counter 20G	B	8.9 lb	1.8				
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	9222 a-d	30.4 bcd	16.83 a	977
Counter 20G	B	8.9 lb	1.8	9131 a-d	30.6 bc	16.48 a	936
Poncho Beta + Counter 20G	Seed B	 5.25 lb	68 g a.i./ unit seed 1.05	9055 a-d	32.0 abc	15.83 ab	834
Poncho Beta + Counter 20G	Seed 3 d Pre-peak Post B	 5.25 lb	68 g a.i./ unit seed 1.05	8895 bcd	30.1 cd	16.40 ab	897
Counter 20G	B	7.5 lb	1.5	8748 b-e	32.0 abc	15.33 bc	745
Poncho Beta + Thimet 20G	Seed 3 d Pre-peak Post B	 7 lb	68 g a.i./ unit seed 1.4	8654 cde	30.7 bc	15.78 ab	789
Poncho Beta	Seed		68 g a.i./ unit seed	8461 de	28.3 d	16.65 a	871
Counter 20G	B	5.25 lb	1.05	7965 ef	30.6 bc	14.58 c	591
Check	---	----	---	7192 f	24.7 e	16.25 ab	704
LSD (0.05)				912.6	2.22	1.105	

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

In comparing dual- and triple-component SBRM control programs, the addition of Lorsban Advanced (1 pt/ac) to plots initially planted with Poncho Beta-treated seed and treated at postemergence with Thimet 20G at 7 lb product per acre resulted in a significant increase in recoverable sucrose yield (i.e., by 919 lb/ac) and $198 in additional revenue when compared to the similar entry that lacked the additional Lorsban application. However, when the initial protection involved Poncho Beta-treated seed combined with a planting-time application of Counter 20G at its high labeled rate (8.9 lb/ac), the addition of a peak-fly application of Lorsban Advanced did not result in a significant increase in recoverable sucrose yield or root tonnage, and it only generated $28 in additional revenue.

Dual-component insecticide programs in Study I that were comprised of Poncho Beta and Counter 20G tended to perform better when Counter was applied at its high labeled rate (8.9 lb product/ac), which resulted in gross economic returns increases by between $23 and $106/ac. Trends also suggested that those programs performed better than when Poncho Beta was used in combination with a single postemergence application of Thimet 20G. However, it should be noted that none of the additional granular applications to plots planted with Poncho Beta-treated seed resulted in statistically significant sucrose yield or root tonnage increases in comparison to those protected by Poncho Beta alone. This could have resulted from the large amount of variability among plots that occurred from irregular spots in the field and overland flooding that occurred due to heavy mid-June rains.

It should be noted that Counter insecticide can only be applied once per year. Therefore, if Counter 20G is applied at planting, it cannot be applied postemergence to the same field. It also bears noting that Counter 20G is now labeled with a 90-day preharvest interval (i.e., PHI, the number of days that must elapse after application before a crop can be harvested) for sugarbeet. This makes Counter a much more feasible product as a postemergence option for sugarbeet root maggot control than it had been in the past, as it previously was labeled with a 110-day PHI. The 90-day PHI should work well for Red River Valley growers choosing to use Counter 20G for SBRM management. Postemergence granule applications for SBRM control in the area are typically most effective if made in late-May to early-June. If this product were to be applied to a field on June 1, the 90-day PHI would expire before September 1, which is typically the earliest that pre-pile sugarbeet harvest operations begin in the Valley.

Study II. This experiment involved evaluations of dual-insecticide programs, comprised of either Counter 20G or Poncho Beta for the planting-time component and Lorsban Advanced, applied at either 1 or 2 pts of product per acre, as the postemergence component, for SBRM control. Results from evaluations of sugarbeet root maggot larval feeding injury in Study II indicated that a moderate level of SBRM larval feeding pressure occurred in this trial. This is supported by the moderate level of root maggot feeding injury (i.e., 5.5 rating on the 0 to 9 scale) recorded for the untreated check plots (Table 3).

All insecticide-treated entries provided significant reductions in SBRM feeding injury when compared to the untreated check. The treatment combination of Counter 20G at planting, plus a postemergence application of Lorsban Advanced at its high (2 pts product/ac) rate, was most effective at preventing SBRM larval feeding injury. This combination resulted in significantly lower feeding injury than the combination of Poncho Beta plus Lorsban Advanced at 2 pts/ac, as well as the single-component program that consisted of just Poncho Beta-treated seed.

Table 3. *Larval feeding injury* in an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence liquid sprays, St. Thomas, ND, 2019 (Study II)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 2 pts	1.8 1.0	1.75 c
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 1 pts	1.8 0.5	2.03 c
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 1 pt	1.5 0.5	2.23 bc
Counter 20G	B	8.9 lb	1.8	2.33 bc
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 2 pts	1.5 1.0	2.35 bc
Counter 20G	B	7.5 lb	1.5	2.40 bc

Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	 1 pt	68 g a.i./ unit seed 0.5	2.75 bc
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	 2 pts	68 g a.i./ unit seed 1.0	3.23 b
Poncho Beta	Seed		68 g a.i./ unit seed	3.28 b
Check	---	----	---	5.50 a
LSD (0.05)				1.096

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Seed = insecticidal seed treatment

Most other dual-insecticide (i.e., seed treatment or granular insecticide at planting plus a postemergence application of Lorsban Advanced at peak SBRM fly activity) programs performed well at protecting roots from SBRM feeding injury. Overall performance patterns suggested two things: 1) the high labeled rate of Counter 20G (8.9 lb product/ac) provided numerically (i.e., not statistically) better root protection than the moderate (7.5 lb/ac); and 2) Counter tended to provide slightly better root protection than Poncho Beta in both single- and dual-insecticide programs. For example, the top six treatments (i.e., lowest SBRM feeding injury) all involved Counter 20G for the planting-time component, including those involving stand-alone planting-time applications of Counter. However, it should be noted that significant differences associated with these trends were rare in Study II.

Yield results for Study II are presented in Table 4. All insecticide programs, irrespective of whether involving a single planting-time product (i.e., seed treatment or granular insecticide), or a combination treatment, provided significant increases in both recoverable sucrose yield and root tonnage in this trial. However, although treatment performance patterns somewhat corresponded with those observed in the root maggot feeding injury rating results, there were no significant differences in recoverable sucrose yield among insecticide-protected treatments. This was probably a result of the major variability among plots within replicates that was prevalent at this location in 2019.

Table 4. *Yield parameters* from an evaluation of sugarbeet root maggot control by combining planting-time insecticide granules or seed treatments with postemergence liquid sprays, St. Thomas, ND, 2019 (Study II)

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 1 pt	1.5 0.5	9876 a	33.9 ab	16.15 a	965
Counter 20G	B	8.9 lb	1.8	9846 a	34.8 a	15.73 a	904
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 2 pts	1.8 1.0	9689 a	33.7 abc	16.05 a	924
Counter 20G	B	7.5 lb	1.5	9642 a	32.1 abc	16.65 a	1002
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	8.9 lb 1 pts	1.8 0.5	9431 a	33.0 abc	15.85 a	888
Counter 20G + Lorsban Advanced	B Peak fly Broadcast	7.5 lb 2 pts	1.5 1.0	9318 a	33.0 abc	15.73 a	852
Poncho Beta	Seed		68 g a.i./ unit seed	9171 a	32.0 bc	15.88 a	866
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	 2 pts	68 g a.i./ unit seed 1.0	9112 a	31.0 c	16.28 a	906
Poncho Beta + Lorsban Advanced	Seed Peak fly Broadcast	 1 pt	68 g a.i./ unit seed 0.5	9027 a	31.5 bc	16.00 a	855
Check	---	----	---	7634 b	27.6 d	15.38 a	669
LSD (0.05)				1192.2	2.79	NS	

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Seed = insecticidal seed treatment

Dual-insecticide (i.e., planting-time plus postemergence) programs tended to provide numerically improved levels of recoverable sucrose yield and root tonnage over single-component programs, but the differences were not statistically significant. Despite a relative lack in significant differences among insecticide treatments, the top-performing treatments with regard to recoverable sucrose yield and root tonnage in Study II included the following:

1) Counter 20G (7.5 lb product/ac, at-plant band) + postemergence Lorsban Advanced (1 pt/ac, peak fly)
2) Counter 20G (8.9 lb/ac, banded at planting)
3) Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (2 pts/ac, peak fly);
4) Counter 20G (7.5 lb/ac, banded at planting)
5) Counter 20G (8.9 lb/ac, banded at planting) + Lorsban Advanced (1 pt/ac, peak fly); and
6) Counter 20G (7.5 lb product/ac, banded at planting) + Lorsban Advanced (2 pst/ac, peak fly).

Although significant yield differences among insecticide treatments were lacking in Study II, it is worth considering the relative gross economic returns provided by various insecticide regimes tested. The aforementioned top-performing treatments generated gross revenue increases of at least $183/ac in comparison to the check, and the increased revenue from the combination of Counter 20G plus a postemergence application of Lorsban Advanced (1 pt product/ac) increased gross revenue by $333/ac. Similarly, the combination of Poncho Beta-treated seed plus Lorsban Advanced at its high (2 pts/ac) rate generated a gross revenue increase of $237/ac over that of the check.

Despite a substantial amount of unplanned variability among plots in these trials, the results of both Studies I and II indicate that effective root maggot control can result in significant yield and revenue increases that would easily justify the cost of control. Our findings also demonstrate that the additional insecticide in dual- and triple-component insecticide programs is likely to be highly beneficial in protecting the crop from major destruction and generating excellent gross return values for the producer. These results also illustrate the economic significance of the root maggot as a major pest of sugarbeet in the Red River Valley. As such, effective management of the sugarbeet root maggot feeding injury is essential to maximizing economic returns in areas affected by this pest.

References Cited:

Boetel, M.A., R. J. Dregseth, and A. J. Schroeder. 2010. Economic benefits of insecticide applications for root maggot control in replanted sugarbeet. J. Sugar Beet Res. 47: 35-49.

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2012. The SAS System for Windows. Version 9.4. SAS Institute Inc., 2002-2012. Cary, NC.

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A 3-YEAR ASSESSMENT OF POSTEMERGENCE LIQUID INSECTICIDE RATES, TIMING, AND PRODUCT ROTATIONS FOR SUGARBEET ROOT MAGGOT CONTROL

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INTRODUCTION

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a major economic pest of sugarbeet in the Red River Valley (RRV) of North Dakota and Minnesota. Sugarbeet root maggot populations in the RRV have been increasingly problematic for many growers during much of the past decade. The relatively common occurrence of high SBRM infestations, and recent increases in the pest's geographic range, suggest that growers will need to be more aggressive with SBRM management to ensure profitability from their sugarbeet crop.

Pest management programs in areas at high risk for damaging SBRM infestations usually begin with either a granular insecticide, a sprayable liquid insecticide, or an insecticidal seed treatment at planting, and they are often followed by one or more additive postemergence insecticide applications if justified by SBRM fly activity levels. The most commonly used approach for postemergence root maggot control in the RRV is a broadcast application of a sprayable liquid insecticide product.

Effective in 2010, the U.S. Environmental Protection Agency required that labeling for all sprayable liquid insecticide products containing the active ingredient chlorpyrifos (e.g., Lorsban 4E, Lorsban Advanced, and all generic versions) include a 10-day reapplication interval. This requires a 10-day period between successive applications of any sprayable liquid insecticide product that contains chlorpyrifos as its active ingredient. However, the potential impact of this restriction, which lengthened the reapplication interval by three days, on efficacy of chlorpyrifos-based control programs was not known. It has been thought that this restriction could impair growers' ability to effectively manage the SBRM with chlorpyrifos-based products, because high fly activity periods usually only persist for about seven days. In an effort to address this potential problem, research was undertaken to achieve the following objectives regarding postemergence SBRM management: 1) determine the most effective timing schemes for repeated applications of Lorsban Advanced sprays that adhere to its 10-day reapplication restriction; 2) assess the impact of application rate on Lorsban Advanced performance; and 3) evaluate Mustang Maxx as a single postemergence tool and as rotated with Lorsban Advanced applications for postemergence SBRM control.

MATERIALS AND METHODS

This field experiment was conducted near St. Thomas (Pembina County), ND during the 2017, 2018, and 2019 growing seasons. Betaseed 89RR52 glyphosate-resistant seed was used for all treatments in 2017 and 2018, and Betaseed 8524 (also glyphosate-resistant) seed was used in 2019. Planting dates were 11, 10, and 15 May in 2017, 2018, and 2019, respectively. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. No insecticide was applied to the outer "guard" rows (i.e., rows one and six) of each plot, as those rows served as untreated buffers. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with three replications of the treatments.

<u>Planting-time insecticide applications</u>. Planting-time applications of Counter 20G were applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using planter-mounted SmartBox™ computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

<u>Postemergence insecticide applications.</u> Additive postemergence insecticides used included Lorsban Advanced and

Mustang Maxx. Treatments that included postemergence applications involved both single and double postemergence spray applications at varying rates. Average postemergence spray applications were made between two, four, and six days ahead of ("Pre-peak") SBRM fly activity (i.e., between 31 May and 14 June), and between one and eight days after ("Post-peak") peak fly activity (i.e., between 8 and 24 June). Liquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS nozzles calibrated to deliver applications in a finished output volume of 10 GPA.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed each year, with ratings being done on 1 August, 31 July, and 30 July in 2017, 2018, and 2019, respectively. Rating procedures consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on 2 October in 2017, 24 September in 2018, and on 19 September in 2019. Harvest procedures began with removal of foliage from all plots immediately before harvest by using a commercial-grade mechanical defoliator. Immediately following defoliation, all beets from the center two rows of each plot were extracted from soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings ($P = 0.2583$), recoverable sucrose yield (P = 0. 0.1507), root yield ($P = 0.0861$), or percent sucrose content data ($P = 0.8346$). As such, three-year combined analyses were performed on all data from this experiment. Treatment means for all response variables were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

RESULTS AND DISCUSSION

Averaged over the three years of this experiment, root maggot feeding injury ratings in the untreated check plots averaged 6.11 on the 0 to 9 scale of Campbell et al. (2000) (Table 1). This indicated that, across years, the SBRM infestations present for this trial were considered moderate. Despite larval feeding pressure only being moderate, all insecticide treatments, including single-, dual-, and triple-insecticide application programs, resulted in significant reductions in SBRM feeding injury when compared to that in the untreated check plots. In nearly all cases, the addition of a postemergence rescue insecticide application provided a significant improvement in protection from SBRM larval feeding injury. The only postemergence components of dual-application (i.e., planting-time plus postemergence) treatments that did significantly improve root protection when compared to similar treatments that only received the planting-time treatment were: 1) a single postemergence application of Lorsban Advanced at the lower (1 pt product/ac) rate; and 2) a single application of Mustang Maxx (4 oz/ac).

Nearly all treatments that included the addition of two postemergence insecticide applications (i.e., either Lorsban Advanced applied twice, or a combination of Lorsban Advanced followed by an application of Mustang Maxx), were statistically superior in reducing SBRM feeding injury when compared to similar treatments that only included the planting-time application of Counter 20G. The following were the only exceptions to this: 1) a dual postemergence application of Lorsban Advanced at 1 pt/ac, where the post sprays were begun later (i.e., 4 days before peak fly activity rather than 6 days pre-peak); and 2) in a rotation of Lorsban Advanced and Mustang Maxx when the Mustang was applied first.

These findings suggest that growers in high-risk areas, where the need for a second post spray is anticipated, should consider applying their first Lorsban spray at least five to six days before peak fly activity, and be prepared to make a second application about ten days later. Another advisable approach is to integrate their chlorpyrifos-based postemergence control strategy with the addition of Mustang Maxx or another pyrethroid insecticide (e.g., Asana); however, the first insecticide in such rotations should involve chlorpyrifos or a similar-performing product. General trends in this trial also suggested that using the maximum rate (2 pts/ac) of Lorsban Advanced tended to provide more root protection than the 1-pt rate. Similarly, the 8.9-lb rate of Counter appeared to be slightly more effective than 7.5 lb; however, none of these differences were statistically significant.

One additional finding from this trial that bears noting is that the more simple SBRM management program comprised of a planting-time application of Counter 20G at its maximum labeled rate (8.9 lb/ac) plus a single postemergence application of Lorsban Advanced at its highest labeled rate (2 pts/ac) was significantly outperformed by any other insecticide program in this trial.

Table 1. ***Larval feeding injury*** **in an assessment of postemergence insecticide spray timing, rate, and frequency impacts on sugarbeet root maggot control, St. Thomas, ND, 2017-2019**

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 6 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	2.57 d
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	2.63 d
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	2.63 d
Counter 20G + Lorsban Advanced + Mustang Maxx	B 2 d Pre-peak Broadcast 3 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	3.03 cd
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 6 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	3.06 cd
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	3.19 cd
Counter 20G + Mustang Maxx + Lorsban Advanced	B 2 d Pre-peak Broadcast 3 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	3.20 cd
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	3.28 cd
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	3.66 bc
Counter 20G	B	8.9 lb	1.8	3.67 bc
Counter 20G + Mustang Maxx	B 2 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	3.70 bc

Counter 20G	B	7.5 lb	1.5	4.14 b
Check	---	---	---	6.11 a
LSD (0.05)				0.746

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Post Broad = postemergence broadcast

Yield results and associated gross economic returns from this trial are presented in Table 2. All single-, dual- and triple-insecticide control programs provided significant increases in both recoverable sucrose yield and root tonnage. As observed with root injury rating data, excellent sucrose and root yields resulted from treatment combinations that included at least one postemergence application of Lorsban Advanced at its high labeled rate (2 pts product/ac). The highest root tonnage yield was achieved by applying Counter 20G at 8.9 lb/ac, and following that with one postemergence application of Lorsban Advanced at 2 pts/ac. However, the best overall treatments in this trial with regard to recoverable sucrose yield included the following (listed in descending order of performance with regard to sucrose yield):

1) planting-time Counter 20G at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced (6 d pre-peak and 4 d post-peak);

2) planting-time Counter 20G at 7.5 lb/ac + two 1-pt/ac postemergence applications of Lorsban Advanced (6 d pre-peak and 4 d post-peak);

3) planting-time Counter 20G at 7.5 lb/ac + two 2-pt/ac postemergence applications of Lorsban Advanced (4 d pre-peak and 6 d post-peak);

4) planting-time Counter 20G at 8.9 lb/ac + one 2-pt/ac postemergence application of Lorsban Advanced (3 d pre-peak);

5) planting-time Counter 20G at 7.5 lb/ac + 1 pt/ac of Lorsban Advanced (2 d pre-peak) + 4 fl oz/ac of Mustang Maxx (3 d post-peak); and

6) planting-time Counter at 7.5 lb/ac + two 1-pt/ac postemergence applications of Lorsban Advanced (4 d pre-peak and 6 d post-peak).

There were no significant differences among the top six treatments with regard to recoverable sucrose yield or root tonnage. However, the best overall performing treatment, in considering protection from SBRM feeding injury, recoverable sucrose yield, and resulting gross revenue was the combination of planting-time Counter 20G at 7.5 lb/ac plus two 2-pt/ac applications of Lorsban Advanced, applied in succession at 6 days pre-peak and 4 days after peak SBRM fly activity. This combination generated \$371/ac more gross revenue than the untreated check plots, and the two additional applications of Lorsban Advanced combined to provide a total of \$241/ac more revenue than that generated by the stand-alone application of the base treatment (i.e., Counter 20G at 7.5 lb product per acre).

Table 2. *Yield parameters* from an assessment of postemergence insecticide spray timing, rate, and frequency impacts on sugarbeet root maggot control, St. Thomas, ND, 2017-2019

Treatment/form	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield	Root yield	Sucrose (%)	Gross Return/ac

				(lb/ac)	(T/ac)		
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 6 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	10,333 a	33.88 ab	16.63 a	$1,188
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 6 d Pre-peak Broadcast 4 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	10,182 ab	33.25 a-d	16.61 a	$1,178
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	7.5 lb 2 pts 2 pts	1.5 1.0 1.0	10,168 ab	33.96 a	16.46 a	$1,136
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	10,015 abc	34.14 a	16.13 a	$1,082
Counter 20G + Lorsban Advanced + Mustang Maxx	B 2 d Pre-peak Broadcast 3 d Post-peak Broadcast	7.5 lb 1 pt 4 fl oz	1.5 0.5 0.025	9,896 a-d	33.60 abc	16.14 a	$1,076
Counter 20G + Lorsban Advanced + Lorsban Advanced	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	7.5 lb 1 pt 1 pt	1.5 0.5 0.5	9,679 a-d	32.26 a-e	16.40 a	$1,085
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 2 pts	1.5 1.0	9,569 bcd	32.67 a-d	16.11 a	$1,031
Counter 20G + Mustang Maxx	B 2 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	9,564 bcd	31.88 cde	16.43 a	$1,072
Counter 20G + Mustang Maxx + Lorsban Advanced	B 2 d Pre-peak Broadcast 3 d Post-peak Broadcast	7.5 lb 4 fl oz 1 pt	1.5 0.025 0.5	9,550 bcd	32.38 a-d	16.11 a	$1,041
Counter 20G + Lorsban Advanced	B 2 d Pre-peak Broadcast	7.5 lb 1 pt	1.5 0.5	9,407 cde	31.94 b-e	16.11 a	$1,023
Counter 20G	B	8.9 lb	1.8	9,241 de	31.43 de	16.21 a	$1,002
Counter 20G	B	7.5 lb	1.5	8,845 e	30.33 e	16.08 a	$947
Check	---	---	---	7,636 f	26.17 f	15.91 a	$817
LSD (0.05)				702.8	2.35	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; Post Broad. = postemergence broadcast

As observed in root injury rating results, general patterns of performance with regard to yield parameters suggested the following conclusions: 1) a SBRM control program comprised of a moderate rate (i.e., 7.5 lb product/ac) of Counter 20G plus two postemergence sprays of Lorsban Advanced at its high rate (2 pts/ac) is an effective approach that should provide excellent root protection and resulting yield and revenue; 2) the first of two postemergence sprays of chlorpyrifos (i.e., Lorsban Advanced or 4E, or a generic equivalent) should be applied early (i.e., about 6 days before peak fly); 3) a simple SBRM control program involving Counter 20G at its high labeled rate (8.9 lb/ac) plus a single application of a chlorpyrifos spray can provide good control and resulting yield/revenue benefits; and 4) rotating successive postemergence insecticide applications by first applying a chlorpyrifos-based product, then following it within about 4 to 5 days with Mustang Maxx or another pyrethroid product (e.g., Asana XL) should be an effective SBRM control strategy that will also help prevent or delay insecticide resistance development in SBRM populations. NOTE: results from this trial and from previous evaluations suggest that, in rotations between chlorpyrifos and pyrethroid insecticides for SBRM control, applying the chlorpyrifos first (e.g., two to three days before peak fly activity) in the scheme.

Overall, most of the SBRM control programs evaluated in this experiment, especially those involving dual- and triple-component insecticide applications, provided effective SBRM control that resulted in major yield and revenue benefits. Another general conclusion that can be drawn is that the root protection, yield, and revenue benefits from additive postemergence insecticides demonstrate that they are cost-effective tools that easily pay for themselves, even under moderate SBRM larval infestations.

References Cited:

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2012. The SAS System for Windows. Version 9.4. SAS Institute Inc., 2002-2012. Cary, NC.

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EXPERIMENTAL INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL: COMBINED RESULTS FROM FOUR YEARS OF SCREENING

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INTRODUCTION

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is the most economically damaging insect pest of sugarbeet in the Red River Valley (RRV) production area. Economically significant SBRM infestations are relatively common on between 50,000 and 85,000 RRV sugarbeet acres each year. A limited number of insecticide tools are currently registered by the U.S. Environmental Protection Agency (EPA) for root maggot management. Moreover, the small number of options available for SBRM control have mostly involved the same insecticide mode of action (i.e., acetylcholinesterase [ACHE] inhibition) for well over 40 years.

In the many fields where severe SBRM infestations develop each year, a common control approach involves two to three applications of ACHE-inhibiting insecticides within the same growing season to protect the crop from major economic loss. This long-term pattern of repeated use of ACHE inhibitors has exerted intense selection pressure for the development of insecticide resistance in RRV root maggot populations. As such, research on alternative tools and tactics for SBRM management is critically needed to preserve the long-term sustainability and profitability of sugarbeet production for growers affected by this pest. This experiment was carried out to achieve the following objectives: 1) screen several natural and/or botanical insecticides for efficacy at managing the sugarbeet root maggot; and 2) evaluate commercially available, EPA-labeled conventional chemical insecticides that are currently not registered for use in sugarbeet to determine if their performance would warrant future pursuit of labeling for use in the crop for SBRM control.

MATERIALS AND METHODS

This experiment was carried out on grower-owned field sites near St. Thomas (Pembina County), ND during the 2016, 2017, 2018, and 2019 growing seasons. Respective planting dates for these study years were May 10, 11, 14, and 15 May. All plots were planted with glyphosate-resistant seed (i.e., Betaseed 89RR52 during 2016 through 2018, and Betaseed 8524 in 2019). Planting was done by using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" rows (i.e., rows one and six) on each side of the plot served as untreated buffers. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments; however, data from two of the least homogeneous replicates (i.e., one from 2018 and one from 2019) in relation to the remainder of the experiment was excluded to remove unwanted variability and to allow for combined analyses of data from all four study years. As a result, all of the analyses were carried out on a total of 14 replicates.

<u>Planting-time insecticide applications</u>. Counter 20G, applied at a moderate labeled rate (7.5 lb product/ac) was used for comparative purposes as a planting-time standard chemical insecticide in this experiment. It was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. The granular application rate was regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system calibrated on the planter immediately before all applications.

Planting-time liquid insecticides screened in this trial included the following: 1) Aza-Direct (active ingredient: azadirachtin, a neem tree-derived insect antifeedant and growth disruptor); and 2) Endigo ZC (a combination insecticide containing lambda-cyhalothrin [a pyrethroid insecticide] and thiamethoxam [a neonicotinoid]). Both at-plant liquid treatments were delivered in 3-inch T-bands over the open seed furrow by using a planter-mounted, CO_2-propelled spray system equipped with TeeJet™ 400067E nozzles. The planting-time liquid insecticide delivery system was calibrated to apply a finished spray volume output of 5 GPA.

Postemergence insecticide applications. Experimental postemergence insecticide treatments in this experiment included the following sprayable liquid products: 1) Captiva (an insect repellent comprised of capsicum [pepper] extract, garlic oil, and soybean oil]); 2) Dibrom Emulsive (a conventional organophosphate insecticide), Ecozin Plus 1.2%ME (azadirachtin); 3) Evergreen Crop Protection 60-6EC (pyrethrum + a synergist), Vydate C-LV (a carbamate insecticide); and Warrior II (a pyrethroid with Zeon U.V. protection). All of these postemergence-applied experimental insecticides were compared with Lorsban Advanced as a postemergence chemical insecticide standard because chlorpyrifos is the most commonly used postemergence liquid insecticide used for SBRM control by RRV growers. In three of the four years, postemergence spray treatments were broadcast-applied at one day before peak SBRM fly activity; the only exception to this was in 2019, in which the majority of post sprays were made one day after peak SBRM fly activity). All postemergence prays were applied from a tractor-mounted, CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ 11001VS nozzles.

All insecticide treatments involved single, stand-alone (i.e., planting-time or postemergence) applications. Specifically, there was no at-plant insecticide in plots assigned to receive a postemergence insecticide, and vice versa.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this trial on August 1 in 2016 and 2017, and on July 31 in both 2018 and 2019. Rating procedures involved randomly selecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and rating them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared according to sugarbeet quality and yield. Plots were harvested on September 19, 25, and 19 in 2016, 2018, and 2019, respectively, and October 2 in 2017. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from the soil using a mechanical harvester, and weighed in the field using a digital scale. A random subsample of 12-18 roots was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings ($P = 0.0563$), recoverable sucrose yield (P = 0. 0.5798), root yield ($P = 0.1332$), or percent sucrose content data ($P = 0.2725$). As such, four-year combined analyses were performed on all data from this experiment. Treatment means for all four response variables were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

RESULTS AND DISCUSSION

As mentioned above, all insecticide entries in this trial were single-component control tools (i.e., none of the planting-time insecticide treatment plots received any postemergence insecticide protection, and none of the postemergence treatment plots had any planting-time protection). This practice is not recommended in high-risk areas such as St. Thomas, where severe SBRM infestations are common. Therefore, the results of this trial should be interpreted with discretion and with the reminder that the overall goal of this research is to determine if any of these products have the potential of providing supplemental SBRM suppression or control as part of future integrated management programs involving both planting-time and postemergence insecticide applications.

The combined results for sugarbeet root maggot feeding injury in this experiment appear in Table 1. The average level of SBRM larval feeding injury recorded for the untreated check was 6.02 on the 0 to 9 scale of Campbell et al. [2000]), which indicated that moderately high SBRM pressure occurred during the 4-year duration of the experiment. All insecticide treatments provided significant reductions in SBRM feeding injury when compared to the untreated check. Despite Counter 20G being applied at a moderate labeled rate (i.e., 7.5 lb product/ac), it provided significantly greater root protection (i.e., lower SBRM feeding injury ratings) than all other insecticide treatments in the experiment. Other insecticides that provided moderately good protection from larval feeding included Endigo ZC, Vydate C-LV, and Lorsban Advanced. It should also be noted that Lorsban Advanced was applied at a moderate labeled rate (1 pt product/ac). In addition to Counter, Endigo, and Vydate, other treatments that were not significantly outperformed by Lorsban Advanced in relation to root protection from SBRM feeding injury included Dibrom, Ecozin Plus, Captiva, Evergreen Crop Protection, and Warrior II.

Table 1. *Larval feeding injury* in an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2016-2019

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	4.08 f
Endigo ZC	3" TB	4.5 fl oz	0.031	4.68 e
Vydate C-LV	1 d Post-peak Broadcast	34 fl oz	1.0	4.91 de
Lorsban Advanced	1 d Peak fly Broadcast	1 pt	0.5	5.00 cde
Dibrom	1 d Post-peak Broadcast	1 pt	1.65	5.24 bcd
Ecozin Plus 1.2% ME	1 d Post-peak Broadcast	56 fl oz	0.044	5.25 bcd
Captiva	1 d Post-peak Broadcast	2 pts		5.29 bcd
Evergreen Crop Protection	1 d Post-peak Broadcast	16 fl oz		5.31 bcd
Warrior ll	1 d Post-peak Broadcast	1.92 fl oz	0.03	5.48 bc
Aza-Direct	3" TB	56 fl oz	0.043	5.50 b
Check	---	---	---	6.02 a
LSD (0.05)				0.487

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band at planting; 3" TB = 3-inch band over open seed furrow at planting; DIF = dribble in-furrow at planting

Yield data from this trial are shown in Table 2. The only entries that provided significant increases in both recoverable sucrose yield and root tonnage when compared to the untreated check were the planting-time application of Counter 20G (7.5 lb product/ac), the T-banded application of Endigo ZC at planting, and postemergence foliar sprays of Vydate C-LV, and Ecozin Plus. Root yield increases from these treatments, in comparison to the untreated check, ranged from 2.7 tons/ac for the Vydate application to a 3.8-ton increase from the planting-time application of Counter. Although Counter 20G-treated plots produced numerically greater sucrose and root yields than those of all other treatments in the experiment, entries that were not significantly outperformed by Counter in relation to recoverable sucrose yield included Endigo ZC, Vydate C-LV, Ecozin Plus, Warrior II, Dibrom, and Lorsban Advanced. However, it is important to also note that applications of Warrior II, Dibrom, and Lorsban Advanced did not provide significant sucrose yield increases over that recorded for the untreated check.

Table 2. ***Yield parameters*** **from an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2016-2019**							
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 20G	B	7.5 lb	1.5	7866 a	27.5 a	15.34 a	812
Endigo ZC	3" TB	4.5 fl oz	0.031	7715 ab	27.4 a	15.36 a	772
Vydate C-LV	1 d Post-peak Broadcast	34 fl oz	1.0	7584 abc	26.4 ab	15.45 a	787
Ecozin Plus 1.2% ME	1 d Post-peak Broadcast	56 fl oz	0.044	7376 a-d	25.6 abc	15.47 a	769
Warrior ll	1 d Post-peak Broadcast	1.92 fl oz	0.03	7348 a-e	26.2 abc	15.21 a	732
Dibrom	1 d Post-peak Broadcast	1 pt	1.65	7323 a-e	25.6 abc	15.35 a	753
Lorsban Advanced	1 d Peak fly Broadcast	1 pt	0.5	7177 a-e	25.0 bc	15.46 a	746
Evergreen Crop Protection	1 d Post-peak Broadcast	16 fl oz		7035 b-e	24.5 bc	15.36 a	730
Captiva	1 d Post-peak Broadcast	2 pts		6882 cde	24.1 bc	15.34 a	706
Aza-Direct	3" TB	56 fl oz	0.043	6826 de	24.6 bc	15.11 a	667
Check	---	---	---	6652 e	23.7 c	15.21 a	660
LSD (0.05)				712.6	2.44	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band at planting; 3" TB = 3-inch band over open seed furrow at planting; DIF = dribble in-furrow at planting

All insecticide-treated entries in this trial involved a single product application. Although this practice is not recommended for sugarbeet production in high-risk SBRM infestation areas, it was employed this trial to isolate the performance of each individual insecticide treatment. As such, all insecticide-treated plots were anticipated to sustain more SBRM feeding injury and yield loss than would be typically incurred in a grower's commercial field. However, the results were somewhat encouraging. Most notable was the fact that two of the top four treatments, in relation to recoverable sucrose and root yield, involved alternative modes of action to the commonly used ACHE inhibitors. Endigo ZC is comprised of two active ingredients (thiamethoxam [a neonicotinoid insecticide] and lambda-cyhalothrin (a pytrethroid); whereas, the active ingredient in Ecozin Plus is azadirachtin (a plant-derived alkaloid with insecticidal properties).

Plots protected by the T-banded application of Endigo generated $772 in gross economic return per acre, which was an increase of $112/ac when compared to the untreated check. Similarly, plots treated with a single postemergence broadcast application of Ecozin Plus produced $769/ac in gross revenue, which involved a revenue improvement of $109/ac over that of the untreated check. Most of the other insecticide treatments generated revenue increases of between $46 and $127/ac when compared to the untreated check. The exception was Aza-Direct, which was not significantly different from the untreated check recoverable sucrose yield or root tonnage, and only generated $7/ac in increased gross economic return.

These results provide some encouragement regarding the future of SBRM management. Five of the experimental/alternative treatments generated numerically, albeit not statistically, more recoverable sucrose than Lorsban Advanced (the postemergence broadcast spray standard in this trial), and none of these treatments were significantly outperformed with regard to root protection or resulting yield by Counter 20G (the conventional planting-time standard). However, we remind the reader that both Counter 20G and Lorsban Advanced were applied at moderate rates, and not the maximums allowed on the respective labels of those products.

Further testing should be carried out on these and other experimental materials to identify viable alternatives to the currently used insecticides. The use of alternative insecticide active ingredients in place of the long-used ACHE inhibitors could help prevent or delay the development of insecticide resistance in SBRM populations. Products formulated with active ingredients belonging to these alternative modes of action could also provide viable tools for growers to sustainably and profitably produce sugarbeet in areas affected by this pest if the currently available conventional insecticides become unavailable in the future due to regulatory action or voluntary cancellations by their manufacturers.

References Cited:

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2008. The SAS System for Windows. Version 9.2. SAS Institute Inc., 2002-2008. Cary, NC.

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MIDAC FC® INSECTICIDE FOR SUGARBEET ROOT MAGGOT CONTROL: RESULTS FROM A TWO-YEAR SCREENING TRIAL

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INTRODUCTION

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the key insect pest of sugarbeet in the Red River Valley (RRV) growing area. In areas at moderate to high risk of damaging SBRM infestations, RRV sugarbeet producers typically manage this pest by initially using either a granular, liquid, or seed treatment insecticide during planting operations. Additionally, in cases where moderately high to severe SBRM fly infestations develop, one to two postemergence insecticide applications are necessary to protect the crop from major yield and revenue loss. Since the mid-1970s, most of these applications have involved the use of insecticides in the organophosphate and carbamate classes to manage the sugarbeet root maggot. Both of these insecticide classes kill insects through the same mode of action, which is acetylcholinesterase (ACHE) inhibition.

Grower dependence on this single insecticide mode of action for SBRM control in the Red River Valley has been largely due to two factors. First, a limited number of insecticide products have been registered for use in the crop for several decades. Second, despite frequent screening efforts on a variety of insecticides belonging to other modes of action, very few candidate insecticide products tested have shown promise as viable alternatives for SBRM control. As a result of this long-term, repeated use of ACHE inhibitor insecticides, the threat of insecticide resistance development in RRV sugarbeet root maggot populations has been a serious concern of pest management advisors and producers for several years.

In 2019, the U.S. Environmental Protection Agency (EPA) approved the registration of Midac FC for use in sugarbeet and potato. Although the current EPA-issued Midac FC label does not specifically list sugarbeet root maggot as a target pest, Vive Crop Protection has issued a Section 2(ee) recommendation for planting-time applications of this product for SBRM control. The 2(ee) recommendation is a legal designation, offered to end-users by the registrant, as permitted by EPA through statutory authority under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1910. The FIFRA 2(ee) designation allows a user to apply "*a pesticide against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling, unless the Administrator has required that the labeling specifically state that the pesticide may be used only for the pests specified on the labeling after the Administrator has determined that the use of the pesticide against other pests would cause an unreasonable adverse effect on the environment*." This provides legal permission for producers and other applicators to use Midac FC for sugarbeet root maggot management in sugarbeet. However, they must be in physical possession of the published 2(ee) recommendation/product bulletin at the time the product is being applied.

Imidacloprid, the active ingredient in Midac FC, belongs to the neonicotinoid insecticide class, which involves a different mode of action in insects (i.e., antagonism of the postsynaptic nicotine acetylcholine receptor in the central nervous system). Although neonicotinoids offer an alternative action mode, it should be noted that insecticides from this class have been widely used as seed treatments for insect management in sugarbeet since 2008. As such, although Midac FC provides an alternative to the ACHE inhibitors, which have been used for more than four decades, it does not offer a truly novel insecticide mode of action for SBRM management.

This project was carried out to evaluate the efficacy of Midac FC, and also Bifender FC, which is <u>not yet registered</u> for use in sugarbeet, as planting-time insecticides for sugarbeet root maggot control. A secondary objective was to determine the compatibility of these products with 10-34-0 starter fertilizer in planting-time applications (only tested in 2018).

MATERIALS AND METHODS

This two-year experiment was conducted on grower-owned field sites near St. Thomas in rural Pembina County, ND during the 2018 and 2019 growing seasons. Betaseed 89RR52 glyphosate-resistant seed was used for all treatments in 2018, and Betaseed 8524 (also glyphosate-resistant) was the variety used in 2019. Plots were planted on 14 May in 2018, and on 15 May in 2019. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide, with the four centermost rows treated. Insecticide was excluded from each of the outside rows (i.e., rows 1 and 6) of the planter, and those "guard rows" served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free by using periodic cultivation throughout the growing season. The experiment was arranged in a randomized complete block design with three replications of the treatments.

Planting-time insecticide applications: Planting-time applications of Counter 20G were applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using planter-mounted SmartBox™ computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

Planting-time liquid insecticides included Bifender FC (active ingredient bifenthrin, a pyrethroid insecticide), and Midac FC (active ingredient imidacloprid, a neonicotinoid). In 2018, all treatments involving Bifender and Midac were applied in a 100% 10-34-0 (N-P-K) starter fertilizer solution through Teejet™ 650067 flat fan nozzles. In 2019, all planting-time applications of Midac FC and Bifender FC were applied in a 100% water-based (i.e., no starter fertilizer) spray solution, and the water used was adjusted to pH 6.0 about one week before use. All planting-time liquid insecticides were applied in a finished spray volume output of 5 GPA during both test years.

Bifender FC was applied by using both dribble-in-furrow (DIF) and T-band placement, whereas Midac was only applied via DIF placement. T-band placement was achieved by orienting the output fan of each nozzle (TeeJet™ 400067E) to be directly perpendicular to the row, and nozzle height was adjusted on each row to achieve a 3-inch band over the open seed furrow. Dribble in-furrow applications were made by orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No.29 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes. To establish consistent fertility for all treatments, the same rate of starter fertilizer was also applied to Counter-treated plots and the untreated checks. An additional no-fertilizer control was included in 2018 to monitor for potential phytotoxicity; however, none was detected, so that treatment was eliminated from the final combined two-year data analysis.

Root injury ratings: Sugarbeet root maggot feeding injury ratings were conducted on 31 July each year. Sampling consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Plots were harvested on 25 September in 2018, and on 19 September in 2019. Immediately (i.e., between 10 and 60 min) before harvest of each year, all foliage was removed from plots by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were then extracted from soil using a mechanical harvester and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) according to the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings (P = 0.1766), recoverable sucrose yield (P = 0. 3397), root yield (P = 0.1412), or percent sucrose content data (P = 0.1264). As such, two-year combined analyses were performed on all data from this experiment.

RESULTS AND DISCUSSION

Results from sugarbeet root maggot feeding injury ratings in this two-year trial are presented in Table 1. Moderate to high SBRM infestations were present during these evaluations, with feeding pressure in 2018 being higher than that observed in 2019. Averaged across years, the SBRM feeding injury rating for the untreated check plots was 6.17 on the 0 to 9 scale of Campbell et al. [2000]).

All insecticide treatments in this study provided significant reductions in SBRM feeding injury when compared to that recorded for the untreated check plots. The lowest average root maggot feeding injury was observed in plots protected by the T-banded application of Bifender FC (the only experimental product (i.e., not registered for use in sugarbeet) screened in the experiment. The level of root protection provided by the T-banded application of Bifender was significantly greater (i.e., lower larval feeding injury) than that provided by Midac and the dribble-in-furrow (DIF) application of Bifender. Counter 20G also provided good root protection, despite being applied at a moderate labeled rate (7.5 lb product/ac), and it was not significantly outperformed by the T-banded application of Bifender. Also, there was no significant difference between DIF applications of Midac FC and Bifender FC when both products were applied by using DIF placement.

Table 1. *Larval feeding injury* from a two-year field trial on Midac FC, Bifender FC, and Counter 20G for sugarbeet root maggot control, St. Thomas, ND, 2016 – 2017

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Bifender FC	3" TB	7.84 fl oz	0.107	3.53 c
Counter 20G	B	7.5 lb	1.5	4.23 bc
Midac FC	DIF	13.6 fl oz	0.179	4.52 b
Bifender FC	DIF	7.84 fl oz	0.107	4.83 b
Check	---	---	---	6.17 a
LSD (0.05)				0.710

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = 5-inch band; 3" TB = 3-inch T-band; DIF = dribble in-furrow

Yield data from this experiment are shown in Table 2. All insecticide treatments, except the DIF application of Bifender FC, provided significant increases in recoverable sucrose yield in comparison to the untreated check. Plots protected by the T-banded application of Bifender produced significantly greater recoverable sucrose yield than all other insecticide treatments in the study, including Midac FC and the moderate rate (7.5 lb/ac) of Counter 20G. Applying Bifender via T-band placement was also statistically superior to DIF placement of Bifender in relation to both recoverable sucrose yield and root yield. Plots protected by the T-banded application of Bifender FC produced significantly greater root yields than all other treatments in the experiment, except those treated with Midac. Additionally, the T-banded application of Bifender was the only treatment in the trial that resulted in statistically greater root yield than the untreated check.

Table 2. *Yield parameters* from a two-year field trial on Midac FC, Bifender FC, and Counter 20G for sugarbeet root maggot control, St. Thomas, ND, 2016 – 2017							
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return/ ac**
Bifender FC	3" TB	7.84 fl oz	0.107	8899 a	30.2 a	16.18 a	$1,141
Midac FC	DIF	13.6 fl oz	0.179	8009 b	27.7 ab	16.18 a	$1,001
Counter 20G	B	7.5 lb	1.5	7904 b	27.5 b	16.00 a	$984
Bifender FC	DIF	7.84 fl oz	0.107	7092 c	25.4 b	15.68 a	$845
Check	---	---	---	6991 c	25.2 b	15.63 a	$823
LSD (0.05)				748.7	2.54	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

[a]B = banded at planting; Seed = insecticidal seed treatment

Although all insecticide treatments in this trial involved a single application, which is not recommended for areas at risk of to high SBRM population pressure, most of them provided excellent increases in gross economic return. The top-performing treatment, T-banded Bifender FC, generated $1,141 in gross revenue, which was an increase of $318/ac when compared to the untreated check. Similarly, the Midac FC application resulted in a revenue increase of $178/ac, and the Counter treatment improved gross economic return by $161/ac. As such, these treatments would have easily paid for themselves in the added revenue.

Bifender FC tended to perform better than most treatments in this experiment when it was applied by using T-band placement; however, our overall results (i.e., root injury ratings and yield data) suggest that Midac FC was also providing moderate levels of SBRM control. This was demonstrated by two factors. The first was the fact that Midac-treated plots produced significantly more recoverable sucrose yield (i.e., an additional 1,018 lb/ac) than the untreated check plots and the DIF application of Bifender. Secondly, the recoverable sucrose and root yields produced by Midac-treated plots were not significantly different from those produced by plots protected by the moderate rate (7.5 lb product/ac) of Counter 20G. Additional testing on Midac should include comparisons of T-band versus DIF placement to determine the most effective approach at applying this new sugarbeet insecticide.

Overall, our findings suggest with fairly strong likelihood that combining Midac with other pest management tools, such as a postemergence rescue insecticide application if the infestation warrants it, should enable producers to successfully protect their sugarbeet crop from otherwise economically damaging SBRM populations. Moreover, such programs, which integrate different insecticide modes of action, should be used by RRV sugarbeet growers to help slow or prevent the onset of insecticide resistance in area populations of the sugarbeet root maggot.

Finally, it is critical to state that, although it performed well in this experiment when applied as a T-band, <u>Bifender FC is not yet registered for use in sugarbeet</u>, and it is uncertain as to whether it ever will be. As such, until it receives registration for sugarbeet, applying Bifender to the crop would be an illegal application that could lead to a serious fine and also condemnation of the harvest from the affected field.

References Cited:

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

SAS Institute. 2012. The SAS System for Windows. Version 9.4. SAS Institute Inc., 2002-2012. Cary, NC.

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SPRINGTAIL CONTROL IN THE MONDAK SUGARBEET PRODUCTION AREA: A COMPARISON OF GRANULAR, SPRAYABLE LIQUID, AND SEED-APPLIED INSECTICIDES

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INTRODUCTION

Springtails belong to the order Collembola, an order of organisms that is so unique that they are technically not true insects. These tiny, nearly microscopic, blind, and wingless insects spend their entire lives below the soil surface (Boetel et al. 2001). Subterranean springtails tend to thrive in heavy soils with high levels of soil organic matter. Cool and wet weather can be conducive to buildups of springtail infestations because such conditions slow sugarbeet seed germination and seedling development, which renders plants extremely vulnerable to attack by springtails that are not negatively impacted by cool temperatures. Therefore, these pests can cause major stand and yield losses.

Subterranean (soil-dwelling) springtails have been recognized as a serious pest threat of sugarbeet for many growers in the central and southern Red River Valley of Minnesota and North Dakota since the late-1990s. However, in recent years, sugarbeet producers in the western ND and eastern Montana (MonDak) growing area have also experienced significant yield and revenue losses due to major springtail infestations. In some cases, the infestations have been sufficiently severe as to result in failures of some insecticidal approaches aimed at controlling them. We conducted a field experiment in the MonDak growing area to achieve the following objectives in relation to MonDak-area springtail infestations: 1) screen the performance of Counter 20G, a conventional granular insecticide, at different application rates; 2) evaluate the efficacy of both T-banded and dribble in-furrow applications of Mustang Maxx liquid insecticide at its maximum labeled rate; 3) compare the efficacy provided by neonicotinoid insecticidal seed treatments (i.e., Cruiser, NipsIt Inside, and Poncho Beta); and 4) determine if springtail management in sugarbeet can be optimized by combining a planting-time application of Mustang Maxx with Poncho Beta-treated seed.

MATERIALS AND METHODS

This experiment was established in a grower-owned sugarbeet field near Trenton (Williams County) in northwestern, ND. Plots were planted on 2 May, 2019 using a 6-row Monosem NG Plus 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Betaseed 8524, a glyphosate-tolerant seed variety, was used for all treatments. Individual treatment plots were two rows (22-inch spacing) wide and 25 feet long, and 25-ft wide tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments.
NOTE: Two-row plots are the preferred experimental unit size in springtail trials because infestations of these pests are typically patchy. A smaller test area increases the likelihood of having a sufficiently uniform springtail infestation among plots within each replicate of the experiment.

Insecticidal seed treatment materials were applied to seed by Germain's Technology Group (Fargo, ND). Counter 20G insecticide granules were applied by using band placement (Boetel et al. 2006), which consisted of 5-inch swaths delivered through Gandy™ row banders. Planting granular output rates were regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications.

Bifender FC was applied as 3-inch T-bands or by using dribble-in-furrow (DIF) placement. T-band placement was achieved by orienting the output fan of each nozzle (TeeJet™ 400067E) to be directly perpendicular to the row, and nozzle height was adjusted on each row to achieve the desired 3-inch band width over the open seed furrow. Dribble in-furrow applications were made by orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No.29 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes.

Treatment efficacy was compared by using surviving plant stand counts because subterranean springtails cause early-season stand losses that can lead to yield reductions. Stand counts involved counting all living plants within each 25-ft-long row. Plant stand counts were taken on 15, 21, and 29 May, 2019, which were 13, 19, and 27 days after planting (DAP), respectively. Raw stand counts were converted to plants per 100 linear row feet for the analysis. All stand count data were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2008), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

RESULTS AND DISCUSSION

Plant stand count data for this trial appear in Table 1. The treatments in the table are presented in descending order of performance as observed at the last stand count (27 DAP). As such, the best-performing treatment is listed in the top row, and the treatment in which the lowest surviving plant stands were observed appears in the bottom row.

Table 1. *Plant stand counts* from a field trial on planting-time granular, liquid, and seed treatment insecticides for springtail control, Trenton, ND, 2019

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb ai/ac)	Stand count[b] (plants / 100 ft)		
				13 DAP[c]	**19 DAP[c]**	**27 DAP[c]**
Mustang Maxx	3" T-band	4 fl oz	0.025	121.3 a	180.7 a	224.7 a
Poncho Beta + Mustang Maxx	Seed 3" T-band	 4 fl oz	68 g a.i./ unit seed 0.025	120.7 a	180.7 a	218.7 ab
Counter 20G	B	7.5 lb	1.5	136.0 a	182.0 a	216.7 ab
Counter 20G	B	4.5 lb	0.9	124.7 a	174.0 ab	214.0 abc
Counter 20G	B	5.9 lb	1.2	113.3 a	186.7 a	210.0 a-d
Poncho Beta + Mustang Maxx	Seed DIF	 4 fl oz	68 g a.i./ unit seed 0.025	106.0 a	180.0 a	208.7 a-e
NipsIt Inside	Seed		60 g a.i./ unit seed	112.7 a	172.0 ab	204.7 b-f
Cruiser 5FS	Seed		60 g a.i./ unit seed	74.7 a	139.3 c	195.3 c-f
Mustang Maxx	DIF	4 fl oz	0.025	111.3 a	142.7 c	191.3 def
Poncho Beta	Seed		68 g a.i./ unit seed	110.7 a	155.3 bc	190.0 ef
Untreated check	---	----	---	111.3 a	152.7 bc	188.7 f
LSD (0.05)				NS	22.99	19.93

Means within a column sharing a letter are not significantly ($P = 0.05$) different from each other (Fisher's Protected LSD test).

[a]B = banded at planting; T-band = 3" swath over open seed furrow at planting; Seed = insecticidal seed treatment

[b]Surviving plant stands were counted on May 15, 21, and 29, 2019 (i.e., 13, 19, and 27 days after planting, respectively).

[c]DAP = Days after planting

At the initial stand count (13 DAP) there were no significant differences in plant densities between treatments; however, performance patterns observed at that time suggested that the T-banded application of Mustang Maxx was providing slightly better seedling protection than the dribble in-furrow (DIF) application of Mustang. Another general pattern observed was that Counter 20G provided slightly, albeit not significantly, better stand protection than the insecticidal seed treatments and DIF-applied Mustang Maxx.

The highest plant stands at the second stand count date (19 DAP) were recorded in plots protected by the following treatments: 1) Counter 20G (5.9 and 7.5 lb product/ac); 2) T-banded Mustang Maxx; 3) T-banded Mustang Maxx + Poncho Beta-treated seed; and 4) DIF-applied Mustang + Poncho Beta-treated seed. These treatments were statistically superior to all other treatments in the trial at 19 DAP, except Counter 20G at 4.5 lb product per acre and NipsIt Inside. Treatments that failed to show a significant increase in surviving plant stands when compared to the untreated check at 19 DAP included the following (listed in decreasing order of performance): Cruiser 5FS seed treatment, the DIF application of Mustang Maxx, Poncho Beta alone, NipsIt Inside, and the low (4.5 lb/ac) rate of Counter 20G.

At the final stand count (27 DAP), the highest stand protection occurred in plots protected by the following treatments (ranked in descending order of performance): 1) T-banded Mustang Maxx; 2) T-banded Mustang Maxx + Poncho Beta-treated seed; 3) Counter 20G at 7.5 lb/ac; 4) Counter 20G at 4.5 lb/ac; 5) Counter 20G at 5.9 lb/ac; and 6) the DIF application of Mustang Maxx. Although these top six treatments were not significantly different from each other in stand protection, performance patterns observed during the first two stand counts were repeated, and suggested that the 3-inch T-band was generally superior to DIF placement for applying Mustang Maxx. A second general observation that was that planting-time applications of Counter 20G tended to perform better than insecticidal seed treatments, and all rates of Counter 20G resulted in significantly greater plant stands than Poncho Beta. Another overall finding was that there were no statistical differences among insecticidal seed treatments, although trends suggested slightly better performance from NipsIt Inside than the other seed treatment insecticides.

These findings demonstrate the significance of subterranean springtails as serious economic pests of sugarbeet and also illustrate the importance of effectively managing them. MonDak area growers planning to grow sugarbeet in areas with a known history of problems with springtails, especially in areas of reported seed treatment insecticide failures, should seriously consider using one of the better-performing control tools from this trial. If choosing to use a planting-time application of Mustang Maxx, it is strongly recommended that the product be applied in 3-inch T-bands to optimize performance. If that is not a practical option, Mustang Maxx should probably be integrated with a neonicotinoid insecticidal seed treatment of the grower's choosing. Another effective option would be to equip the planter with granular application technology, and protect the crop from springtail infestations with planting-time bands of Counter 20G.

References Cited:

Boetel, M. A., R. J. Dregseth, and M. F. R. Khan. 2001. Springtails in sugarbeet: identification, biology, and management. Extension Circular #E-1205, North Dakota State University Coop. Ext. Svc.

Boetel, M. A., R. J. Dregseth, A. J. Schroeder, and C. D. Doetkott. 2006. Conventional and alternative placement of soil insecticides to control sugarbeet root maggot (Diptera: Ulidiidae) larvae. J. Sugar Beet Res. 43: 47–63.

SAS Institute. 2008. The SAS System for Windows. Version 9.2. SAS Institute Inc., 2002-2008. Cary, NC.

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Entomology Appendix A.: Agronomic, Rainfall, and Plot Maintenance Information
(applies to 2019 experiments only; specific information pertaining to multi-year trials is provided within the respective individual reports)

Location: St. Thomas (Pembina County), ND – Wayne Lessard Farm – *Sugarbeet Root Maggot Trials*

Seed variety: Betaseed 8524

Plot size: Six 35-ft long rows, 4 center rows treated

Design: Randomized complete block, 4 replications

Soil name: Glyndon silt loam

Soil test: Organic matter = 3.4% pH = 7.9

Soil texture: 24.0% sand 57.1% silt 18.9% clay

Previous crop: Wheat (2017)

Soil preparation: Field cultivator (1x)

Planting depth: 1.25"

Herbicides applied:

	June 12	Roundup PowerMAX (32 fl oz/ac) + Outlook (6 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
	July 1	Roundup PowerMAX (26 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)

Rainfall	May 15	0.16”
(after seedbed	May 22	0.22”
preparation)**:**	May 24	0.48”
	May 26	0.04”
	Total/May	**0.90”**

June 3	0.27”
June 4	0.02”
June 7	1.92”
June 8	0.71”
June 15	0.11”
June 16	0.28”
June 17	0.09”
June 21	0.23”
June 22	0.07”
June 24	0.04”
June 25	0.23”
June 29	0.05”
Total/June	**4.02”**
July 1	0.05”
July 8	0.23”
July 9	0.34”
July 10	0.23”
July 11	0.05”
July 25	0.32”
July 28	0.14”
July 31	0.05”
Total/July	**1.41”**
Total/August	**1.74”**
Total/September	**1.76”**
Grand Total	**9.83”**

Damage ratings: July 29 (Study I) and July 31 (Study II)

Harvest date: September 18

Yield sample size: 2 center rows x 35 ft length (70 row-ft total)

Location:	Trenton (Williams County), ND – Joe Mortenson Farm – *Springtail Management Trial*	
Seed variety:	Betaseed 8524	
Plot size:	Six 25-ft long rows, 2 rows treated	
Design:	Randomized complete block, 3 replications	
Soil name:	Havrelon-Lohler fine loam	
Soil test:	Organic matter = 2.0%	pH = 8.3
Previous crop:	Wheat (2018)	
Soil preparation:	Deep ripped (1x)	
	Surface leveler (1x)	
	Mulcher (1x)	
Planting depth:	1.25"	
Planting date:	May 2	
Herbicides applied:	May 6	Roundup PowerMAX (32 fl oz/ac) + Mustang (4 fl oz/ac) + Class Act NG (2.5% v/v)
	June 13	Roundup PowerMAX (32 fl oz/ac) + Class Act NG (2.5% v/v)
Rainfall:	May 2	0.02"
(after seedbed	May 3	0.01"
preparation)**:**	May 4	0.02"
	May 10	0.03”

May 11	0.03”
May 17	0.78”
May 18	0.05”
May 24	0.43”
Total/May	**1.37"**
June 3	0.01"
June 8	0.18"
June 14	0.71"
June 15	0.11"
June 20	0.46"
June 21	0.84"
June 22	0.05"
June 23	0.03”
June 24	0.08”
June 28	1.03”
June 29	0.15”
Total/June	**3.65"**
Total/July	**3.38"**
Total/August	**2.22"**
Total/September	**7.90"**
Total/October	**0.63”**

Stand counts: May15, 21, and 29

Harvest: not harvested

Entomology Appendix B. 0 to 9 Scale for Rating Sugarbeet Root Maggot Feeding Injury

Treatment performance in preventing sugarbeet root maggot feeding injury was quantified for all root maggot control trials by rating beets on the 0 to 9 root injury rating scale of Campbell et al. (2000). Criteria for respective points on the scale are as follows:

0 = no scars

1 = 1 to 4 small (pin head size) scars

2 = 5 to 10 small scars

3 = 3 large scars or scattered small scars

4 = few large scars and /of numerous small scars

5 = several large scars and/or heavy feeding on laterals

6 = up to 1/4 root scarred

7 = 1/4 to 1/2 of root blackened by scars

8 = 1/2 to 3/4 root blackened by scars

9 = more than 3/4 of root area blackened

Reference Cited:

Campbell, L. G., J. D. Eide, L. J. Smith, and G. A. Smith. 2000. Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae*. J. Sugar Beet Res. 37: 57–69.

PLANT PATHOLOGY

NOTES

TURNING POINT SURVEY OF FUNGICIDE USE IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2018

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The fourth annual fungicide practices live polling questionnaire was conducted using Turning Point Technology at the 2019 Winter Sugarbeet Growers' Seminars held during Jan and Feb 2019. Responses are based on production practices from the 2018 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND and Willmar, MN Grower Seminars. Respondents from each seminar indicated the county in which the majority of their sugarbeets were produced (Tables 1- 5). The average sugarbeet acreage per respondent grown in 2018 was calculated from Table 6 at between 400 and 599 acres.

Survey participants were asked about soilborne diseases and control practices. Sixty-nine percent said their fields were affected by Rhizoctonia, 15% said Aphanomyces was the biggest issues, 10% said they had issues with multiple diseases including Rhizoctonia, Aphanomyces, Fusarium and Rhizomania, 4% said they had no soilborne disease issues, and 1% each listed either Fusarium or Rhizomania as their biggest issue (Table 7). Additionally, participants were asked about the prevalence of Rhizoctonia in sugarbeet with which preceding crops. Sixty one percent of respondents said they saw more rhizoctonia when soybeans preceded their sugarbeet crop. Twelve percent reported more Rhizoctonia following dry beans, 11% saw more Rhizoctonia following a field corn crop, 9% said any crop, 4% said potatoes, 1% each stated sweet corn, small grains or other as the crop preceding sugarbeets they saw the most Rhizoctonia develop (Table 8). Of the respondents to the question regarding specialty variety used for Rhizoctonia, 76% respondents said yes they did use a specialty variety for Rhizoctonia while 24% said no (Table 9).

Participants were asked what methods were used to control Rhizoctonia and 42% said they used a seed treatment only, 36% used a seed treatment and a POST fungicide, 12% used a seed treatment plus an in-furrow fungicide while 9% also said they used a seed treatment, in-furrow fungicide and a POST fungicide, and 1% said they used seed treatment, in-furrow and a double POST application (Table 10). Seventy two percent of respondents used a Kabina seed treatment while 15% used Metlock Suite + Kabina, 8% used Systiva, 3% used Vibrance, and 2% used Metlock Suite and Vibrance (Table 11). Eighty three percent used an in-furrow starter fertilizer and 17% did not (Table 12). Of the respondents who applied an in-furrow fungicide, 21% used Quadris or generic, 7% used other fungicide and 4% used Headline or generic; 68% of respondents used no fungicide in-furrow (Table 13).

Respondents were asked what POST fungicides were used to control Rhizoctonia and 39% did not use a POST fungicide to control Rhizoctonia. Forty-eight percent used Quadris or generic, 7% used Proline, 4% used Priaxor, 1% used other POST fungicide and >1% used Headline (Table 14). Participants were then asked to grade the effectiveness of the POST fungicides that were used. Thirty-eight percent received good results, 38% said they were unsure of their results, 12% reported fair results, 7% said the fungicides performed excellently and 5% said they performed poorly (Table 15). Respondents were also asked how they applied POST fungicide and 52% stated they used band and 48% used a broadcast application (Table 16).

Participants were also asked about use of waste lime to control Aphanomyces. Sixty-three percent of participants did not use waste lime in their fields while 28% used between 6 and 10 tons/acre while 9% used less than 5 tons/acre (Table 17). Respondents were also asked about their soil pH. Forty-six percent said it was between 7.5 and 8.0, 24% said between 8.0 and 8.5, 19% between 7.0 and 7.5, 9% between 6.5 and 7.0, 1% said between 6.0 and 6.5 and another 1% said between 8.5 and 9.0 (Table 18). As a follow-up question, growers were asked whether or not they were concerned about using waste lime on soils above 8.0 pH. Seventy-seven percent said no while the remaining

23% said they were concerned (Table 19). Finally, the growers were asked how effective their waste lime application was. Forty-five percent of respondents did not apply lime, 21% said they had good results, 19% said excellent, 11% were unsure, 3% reported fair results and 1% said poor (Table 20).

One of the survey questions also asked if growers had used a specialty variety for Aphanomyces in 2018. Sixty-three percent of respondents said yes and 37% said no (Table 21).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on sugarbeet in 2018. Twenty-five percent said that they used 4 sprays to control CLS, 19% used three applications, 18% used two applications, 15% used five applications, 11% used six applications, 5% used one application, 4% used seven applications, 1% did not use a CLS application and 1% applied more than seven CLS applications (Table 22). Respondents were then asked about the effectiveness of their CLS sprays. Forty-one percent said they had good results, 21% said they had fair results, 18% reported excellent results, 16% reported poor results, and 4% of respondents were unsure (Table 23).

Respondents were asked about when their CLS application started and ended. Forty-eight percent of participants said that they began their applications between July 1 and 10, 25% said it started between July 11 and 20, 16% said it was between July 21 and 31, 7% said before July 1, 3% said that CLS sprays started between August 1 and 10 and 1% said after August 10 (Table 24). Forty-six percent of respondents said that their last CLS spray was between September 1 and 10, 23% said between August 21 and 31, 17% said between September 11 and 20, 7% said between August 11 and 20, 3% said after September 20, 2% said they only made one or zero CLS applications, 2% said between August 1-10 and >1% before August 1 (Table 25).

Participants were then asked if they experienced field failure and what date that occurred. Fifty-four percent said they did not experience field failure, 17% said it occurred around August 15, 11% said it occurred around August 31, 9% said July 31, 6% said September 15, 2% said after September 30, 1% said around September 30 (Table 26).

Participants were then asked about their specific fungicide use to control CLS. Fifty-eight percent of growers said that their first application was Tin + Topsin, 20% said EBDC + Triazole, 7% said Tin + Triazole, 7% said Tin + EBDC, 7% said they used a single chemistry application and 1% said QOI + other (Table 27). For the second application, 37% of respondents said they used Tin + Topsin, 36% said EBDC + Triazole, 9% said a single chemistry application was used, 6% said Tin + Triazole, 5% said Tin + EBDC, 3% said QOI + other chemistry, 2% said Triazole + Copper, and 1% each said Tin + Copper, EBDC + Copper, and other (Table 28). For the third application, 32% said EBDC + Triazole, 15% said a single chemistry application, 12% used Tin + Triazole, 11% used Tin + EBDC, 9% used Tin + Copper, 8% used Tin + Topsin, 5% used QOI + other chemistry, 5% used an "other" fungicide not listed, 2% said Triazole + Copper and 1% used EBDC + Copper (Table 29). For the fourth application, 18% used Tin + Triazole, 15% used a singly chemistry application, 13% said other, 12% said EBDC + Copper, 11% said EBDC + Triazole, 10% said Triazole + Copper, 7% said Tin + EBDC, 6% said Tin + Copper, 4% said Tin + Topsin and another 4% said QOI + other. (Table 31).

Survey participants were also asked whether they used QoI fungicides for CLS control. Forty-two percent said yes, they used QoI fungicides in a mixture, 38% percent said no, and 20% said they used QoI fungicides alone (Table 32).

Of the total fungicide applications for CLS, 65% did not use an aerial applicator, 22% used an aerial applicator for 1-20% of their applications, 5% used an aerial applicator for 21-40% of their fungicide applications, 4% said they used an aerial applicator for 100% of applications, 2% fell in the 41-60% range, 1% in the 61-80% range, and 1% in the 81-99% range (Table 33).

Regarding water usage in gallons per acre as applied by tractor, 47% of respondents used 11-15 gallons per acre, 41% used 16-20 gallons per acre, 8% used more than 20 gallons per acre, 3% used 6-10 gallons per acre and >1% used 1-5 gallons per acre (Table 34).

Table 1. 2019 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Barnes	-	-
Becker	1	3
Cass	12	32
Clay	10	26
Norman[1]	12	32
Ransom	-	-
Richland	2	5
Steele	-	-
Trail	1	3
Wilkin[2]	-	-
Total	38	101

Table 2. 2019 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Cavalier	-	-
Grand Forks	3	8
Kittson	5	13
Marshall	2	5
Nelson	-	-
Pembina	13	33
Polk	-	-
Ramsey	-	-
Walsh	14	36
Other	2	5
Total	39	100

Table 3. 2019 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Grand Forks	19	21
Mahnomen	1	1
Marshall	9	10
Nelson	-	-
Pennington/Red Lake	1	1
Polk	45	51
Steele	-	-
Traill	2	2
Walsh	4	4
Other	8	9
Total	89	99

Table 4. 2019 Wahpeton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2018.

County	Number of Responses	Percent of Responses
Cass	-	-
Clay	3	10
Grant	4	13
Otter Tail	-	-
Ransom	-	-
Richland	6	20
Roberts	-	-
Stevens	-	-
Traverse	1	3
Wilkin	16	53
Total	30	99

Table 5. 2019 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2018.

County		Number of Responses	Percent of Responses
Chippewa		27	33
Kandiyohi		8	10
Pope		1	1
Redwood		4	5
Renville		26	32
Stearns		-	-
Stevens		5	6
Swift		6	7
Other		4	5
	Total	81	99

Table 6. Total sugarbeet acreage operated by respondents in 2018.

		Acres of sugarbeet									
Location	Responses	<99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		-------------------------------------% of responses----------------------------------									
Fargo	36	6	6	8	3	28	17	6	8	11	8
Grafton	42	5	14	-	10	33	14	17	5	2	-
Grand Forks	83	11	7	5	4	16	20	7	17	8	5
Wahpeton	30	7	3	-	30	20	10	7	13	7	3
Willmar	82	7	12	10	6	17	18	4	15	10	1
Total	273	8	9	5	8	21	17	7	13	8	3

Table 7. What soil-borne diseases affected your sugarbeet production in 2018?

Location	Respondents	Root disease					
		Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	Neither
		-----------------------------% of respondents-------------------------					
Fargo	36	56	11	6	6	17	6
Grafton	42	69	19	2	-	5	5
Grand Forks	88	60	11	-	-	10	7
Wahpeton	30	87	10	-	-	3	-
Willmar	82	68	18	-	1	11	1
Total	278	69	15	1	1	10	4

Table 8. With which of the preceding crops do you see more Rhizoctonia in sugarbeet?

Location	Respondents	Field Corn	Sweet Corn	Soybean	Dry edible beans	Potatoes	Small grains	Other	Any crop
		-------------------------------------% respondents-------------------------------------							
Fargo	31	-	-	7	6	-	6	-	10
Grafton	39	-	3	51	18	21	-	-	8
Grand Forks	65	8	-	60	25	2	-	2	5
Wahpeton	26	27	-	58	-	-	-	-	15
Willmar	72	19	1	63	4	1	-	1	10
Total	233	11	1	61	12	4	1	1	9

Table 9. Have you used a specialty variety for Rhizoctonia in 2018?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	39	74	26
Grafton	40	80	20
Grand Forks	84	73	27
Wahpeton	27	81	19
Total	190	76	24

Table 10. What methods were used to control *Rhizoctonia solani* in 2018?

Location	Respondents	Seed Treatment Only	Seed Treatment + In-Furrow	Seed Treatment + POST	Seed Treatment + In-Furrow + POST	Seed Treatment + In-Furrow + 2x Post
		------------------------------------% respondents------------------------------------				
Fargo	39	36	10	36	18	-
Grafton	41	20	12	59	7	2
Grand Forks	83	28	22	39	12	-
Wahpeton	28	86	4	7	4	-
Willmar	81	54	5	32	5	4
Total	272	42	12	36	9	1

Table 11. Which seed treatment did you use to control *Rhizoctonia solani* in 2018?

		Seed treatment				
Location	Respondents	Kabina	Metlock Suite + Kabina	Vibrance	Systiva	Metlock Suite + Vibrance
		------------------------------% of respondents----------------------------				
Fargo	39	72	8	3	15	3
Grafton	36	72	14	3	8	3
Grand Forks	80	66	21	5	8	-
Wahpeton	29	90	7	-	-	3
Total	184	72	15	3	8	2

Table 12. Did you apply any in-furrow starter fertilizer in 2018?

		Variety type	
Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	40	75	25
Grafton	43	88	12
Grand Forks	81	93	7
Wahpeton	31	65	35
Willmar	82	83	17
Total	277	83	17

Table 13. Which fungicide did you apply in-furrow to control *R. solani* in 2018?

Location	Respondents	In-furrow fungicide use			
		Headline or generic	Quadris or generic	Other	None
		------------------------------% of respondents----------------------------			
Fargo	39	5	26	5	64
Grafton	40	-	30	10	60
Grand Forks	83	5	30	14	51
Wahpeton	30	-	10	3	87
Willmar	82	5	10	1	84
Total	274	4	21	7	68

Table 14. Which POST fungicide did you use to control *R. solani* in 2018?

Location	Respondents	POST fungicide					
		Headline	Quadris	Proline	Priaxor	Other	None
		------------------------------% of respondents----------------------------					
Fargo	38	-	63	5	8	-	24
Grafton	41	-	54	7	15	-	24
Grand Forks	80	-	66	4	1	1	28
Wahpeton	29	-	7	10	3	3	76
Willmar	81	1	35	9	1	1	53
Total	269	>1	48	7	4	1	39

Table 15. How effective were your POST fungicides at controlling *Rhizoctonia solani* in 2018?

Location	Respondents	Effectiveness of fungicides				
		Excellent	Good	Fair	Poor	Unsure
		------------------------------% of respondents----------------------------				
Fargo	34	9	53	15	-	24
Grafton	38	13	58	16	-	13
Grand Forks	72	12	53	7	4	24
Wahpeton	20	-	10	20	-	70
Willmar	69	-	12	13	12	64
Total	233	7	38	12	5	38

Table 16. How did you apply POST fungicide for controlling Rhizoctonia Solani?

Location	Respondents	Band	Broadcast
		------------------------% of respondents------------------------	
Fargo	31	48	52
Grafton	34	50	50
Grand Forks	67	60	40
Wahpeton	10	40	60
Willmar	46	48	52
Total	188	52	48

Table 17. What rate of precipitated calcium carbonate (waste lime) did you use in 2018?

		Lime use rate		
Location	Respondents	None	<5 T/A	5-10 T/A
		------------------------------% of respondents----------------------------		
Fargo	37	57	5	38
Grafton	40	72.5	-	27.5
Grand Forks	84	74	-	26
Wahpeton	31	29	6	65
Willmar	79	65	25	10
Total	271	63	9	28

Table 18. What is your soil pH?

		Soil pH					
Location	Respondents	6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.0	8.0-8.5	8.5-9.0
		------------------------------% of respondents----------------------------					
Fargo	35	3	14	14	34	34	-
Grafton	39	3	10	3	59	23	3
Grand Forks	81	-	6	15	38	40	1
Wahpeton	29	-	7	21	55	17	-
Willmar	82	-	11	32	50	6	1
Total	266	1	9	19	46	24	1

Table 19. Are you concerned about using waste lime on pH soils above 8.0?

Location	Respondents	Safety concerns	
		Yes	No
		---------------------% respondents---------------------	
Fargo	35	23	77
Grafton	36	25	75
Grand Forks	72	15	57
Wahpeton	28	25	75
Total	171	23	77

Table 20. How effective was waste lime at controlling Aphanomyces in 2018?

Location	Respondents	Waste lime effectiveness					
		Excellent	Good	Fair	Poor	Unsure	No Lime
		------------------------------% of respondents----------------------------					
Fargo	37	30	19	3	-	11	38
Grafton	39	13	18	5	-	5	59
Grand Forks	78	13	17	3	1	17	50
Wahpeton	29	28	41	-	-	7	24
Total	183	19	21	3	1	11	45

Table 21. Have you used a specialty variety for Aphanomyces in 2018?

Location	Respondents	Variety type	
		Yes	No
		---------------------% respondents---------------------	
Fargo	36	67	33
Grafton	38	61	39
Grand Forks	75	68	32
Wahpeton	29	52	48
Total	178	63	37

Table 22. How many fungicide applications did you make to control CLS in 2018?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Fargo	40	-	3	10	33	48	8	-	-	-
Grafton	42	-	17	60	21	2	-	-	-	-
Grand Forks	82	2	5	23	28	39	2	-	-	-
Wahpeton	30	-	-	-	10	23	47	20	-	-
Willmar	81	-	2	1	5	14	28	30	15	3
Total	275	1	5	18	19	25	15	11	4	1

Table 23. How effective were your fungicide applications on CLS in 2018?

Location	Respondents	Effectiveness of CLS sprays					
		Excellent	Good	Fair	Poor	Unsure	No applications
		-----------------------------% of respondents-------------------------					
Fargo	40	15	73	13	-	-	-
Grafton	41	27	73	-	-	-	-
Grand Forks	77	36	51	9	-	4	-
Wahpeton	31	3	26	45	19	6	-
Willmar	81	2	6	37	47	7	-
Total	270	18	41	21	16	4	-

Table 24. What date was your first CLS application?

Location	Respondents	Date of first CLS application					
		Before July 1	July 1-10	July 11-20	July 21-31	August 1-10	After August 10
		------------------------------% of respondents------------------------------					
Fargo	38	8	39	32	18	-	3
Grafton	41	-	22	34	32	12	-
Grand Forks	75	1	35	29	28	4	3
Wahpeton	28	21	54	21	-	4	-
Willmar	79	10	75	15	-	-	-
Total	261	7	48	25	16	3	1

Table 25. What date was your last CLS application in 2018?

Location	Respondents	Date of last CLS application							
		Before August 1	August 1-10	August 11-20	August 21-31	Sept 1-10	Sept 11-20	Later than Sept 20	Made zero or 1 CLS applications
		------------------------------% of respondents------------------------------							
Fargo	39	-	-	8	18	44	26	3	3
Grafton	40	-	-	8	33	45	10	3	3
Grand Forks	78	-	4	6	22	53	10	5	-
Wahpeton	29	-	-	-	24	52	21	3	-
Willmar	80	1	1	10	23	40	23	-	3
Total	266	>1	2	7	23	46	17	3	2

Table 26. When did you experience failure of fungicides to control CLS in 2018?

		Date of fungicide failure						
Location	Respondents	No failure	July 31	August 15	August 31	September 15	September 30	After September 30
		-----% of respondents-----						
Fargo	36	81	-	6	3	3	3	6
Grafton	38	87	5	3	-	3	-	3
Grand Forks	77	87	4	-	3	5	1	-
Wahpeton	30	23	3	37	27	7	-	3
Willmar	78	4	22	40	23	10	-	1
Total	259	54	9	17	11	6	1	2

Table 27. What fungicides did you apply with your first CLS application in 2018?

		Fungicide									
Location	Respondents	Tin + Topsin	Tin + EBDC	EBDC + Triazole	Tin + Triazole	Tin + copper	EBDC + Copper	QOI + Other chemistry	Triazole + Copper	Single Chemistry	Other
		-----% of respondents-----									
Fargo	34	56	3	24	3	-	-	3	-	12	-
Grafton	34	65	9	3	21	-	-	-	-	3	-
Grand Forks	76	50	8	30	5	-	-	-	-	7	-
Wahpeton	29	76	7	10	-	-	-	-	-	7	-
Total	173	58	7	20	7	-	-	1	-	7	-

Table 28. What fungicides did you apply with your second CLS application in 2018?

		Fungicide									
Location	Respondents	Tin + Topsin	Tin + EBDC	EBDC + Triazole	Tin + Triazole	Tin + Copper	EBDC + Copper	QOI + Other chemistry	Triazole + Copper	Single Chemistry	Other
		------------------------------% of respondents------------------------------									
Fargo	27	44	4	26	7	-	4	7	4	-	4
Grafton	31	16	3	32	10	-	-	10	-	26	3
Grand Forks	76	49	7	33	5	-	-	-	-	7	-
Wahpeton	27	19	4	60	-	4	-	-	11	4	-
Total	161	37	5	36	6	1	1	3	2	9	1

Table 29. What fungicides did you apply with your third CLS application in 2018?

		Fungicide									
Location	Respondents	Tin + Topsin	Tin + EBDC	EBDC + Triazole	Tin + Triazole	Tin + Copper	EBDC + Copper	QOI + other chemistry	Triazole + Copper	Single Chemistry	Other
		------------------------------% of respondents------------------------------									
Fargo	29	-	10	31	17	7	-	14	3	10	7
Grafton	14	-	-	21	-	-	-	14	-	64	-
Grand Forks	52	4	10	48	13	2	2	-	2	12	8
Wahpeton	26	31		8	8		-		4	-	-
Total	121	8	11	32	12	9	1	5	2	15	5

Table 30. What fungicides did you apply with your fourth CLS application in 2018?

		Fungicide									
Location	Respondents	Tin + Topsin	Tin + EBDC	EBDC + Triazole	Tin + Triazole	Tin + Copper	EBDC + Copper	QOI + other chemistry	Triazole + Copper	Single Chemistry	Other
		-----------------------------% of respondents-----------------------------									
Fargo	16	-	-	6	6	-	-	19	13	44	13
Grafton	1	-	-	-	-	-	-	-	-	-	1
Grand Forks	41	7	12	12	29	2	2	-	2	12	20
Wahpeton	24	-	4	13	8	17	38	-	21	-	-
Total	82	4	7	11	18	6	12	4	10	15	13

Table 31. What fungicides did you apply with your fifth CLS application in 2018?

		Fungicide									
Location	Respondents	Tin + Topsin	Tin + EBDC	EBDC + Triazole	Tin + Triazole	Tin + Copper	EBDC + Copper	QOI + other chemistry	Triazole + Copper	Single Chemistry	Other
		----------------------------% of respondents-----------------------------									
Fargo	5	-	-	-	-	-	40	20	-	20	20
Grand Forks	10	-	10	10	10	-	-	-	-	-	70
Wahpeton	17	6	18	12	6	18	18	-	12	6	6
Total	32	3	13	9	6	9	16	3	6	6	28

Table 32. Did you use any QoI fungicides for CLS control?

		Variety type		
Location	Respondents	No	Yes – in a mixture	Yes - alone
		---------------------% respondents---------------------		
Fargo	30	53	30	17
Grafton	35	46	14	40
Grand Forks	77	18	64	18
Wahpeton	25	68	28	4
Total	167	38	42	20

Table 33. What percent of total fungicide applications for CLS were sprayed by an aerial applicator?

		Percentages						
Location	Respondents	0%	1-20%	21-40%	41-60%	61-80%	81-99%	100%
		----------------------------% of respondents-----------------------------						
Fargo	40	68	8	10	5	-	5	5
Grafton	41	88	5	2	-	-	-	5
Grand Forks	80	70	14	5	2	1	-	8
Wahpeton	30	70	20	3	3	3	-	-
Willmar	82	46	48	5	-	1	-	-
Total	273	65	22	5	2	1	1	4

Table 34. How many gallons of water per acre did you use to apply CLS fungicides by tractor?

		Gallons per acre				
Location	Respondents	1-5	6-10	11-15	16-20	20+
		------------------------------% of respondents----------------------------				
Fargo	36	-	-	51	14	6
Grafton	40	-	3	58	38	3
Grand Forks	73	1	7	64	22	5
Wahpeton	29	-	7	28	59	7
Willmar	81	-	1	19	64	16
Total	259	0.4	3	47	41	8

INTEGRATED MANAGEMENT OF RHIZOCTONIA ON SUGARBEET WITH RESISTANT VARIETIES, AT-PLANTING TREATMENTS, AND POSTEMERGENCE FUNGICIDES

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Rhizoctonia damping-off and crown and root rot (RCRR) caused by *Rhizoctonia solani* AG 2-2 have been the most common root diseases on sugarbeet in Minnesota and North Dakota for several years (1,2). These disease can occur throughout the growing season and reduces plant stand, root yield, and quality (3-6). Warm and wet soil conditions favor infection by *R. solani*. Disease management options include rotating with non-host crops (cereals), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), or postemergence. An integrated approach involving multiple strategies should help managing Rhizoctonia crown and root rot (4-6).

OBJECTIVES

Field trials were established to evaluate an integrated management strategy consisting of a resistant (R) and a moderately susceptible (MS) variety with at-panting treatments alone and in combination with two different postemergence azoxystrobin application timings for 1) control of early-season damping-off and RCRR and 2) effect on plant stand, yield and quality of sugarbeet.

MATERIALS AND METHODS

The field trial was established at three locations: (1) University of Minnesota, Northwest Research and Outreach Center, Crookston, (2) Minn-Dak Farmers Cooperative, Wahpeton (MDFC), ND, (3) Southern Minnesota Beet Sugar Cooperative (SMBSC), Renville, MN. All locations were fertilized for optimal yield and quality. At each location, a combination of a R and MS variety treated with fluxapyroxad (Systiva), in-furrow azoxystrobin (Quadris) on fluxapyroxad (Systiva), or untreated seed was planted in four replicate plots (Table 1). An additional treatment consisting of in-furrow azoxystrobin on untreated seed was included at the NWROC site. Plots were set up in a split-split plot design at all 3 locations. Main plots were varieties, the first split was at-panting treatments, and the last split was postemergence azoxystrobin timings. Systiva was used at 5 g ai/unit seed and applied by Germains Seed Technology, Fargo, ND. Each variety by at-planting treatment combination was planted in triplicate, so that at the 4- or 8-leaf stage, one plot of each variety by at-planting treatment combination received a postemergence 7-inch band application of azoxystrobin (14.3 fl oz product A^{-1}) while one was left as a stand-alone treatment. Controls for each variety included no at-planting treatment with each postemergence azoxystrobin timing and without postemergence azoxystrobin. Two-year average Rhizoctonia ratings in American Crystal Sugar Company tests for the R and MS varieties were 3.9 and 4.5, respectively (7).

NWROC site. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley broadcast at 40 kg ha^{-1} and incorporated with a Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 16 at 4.5-inch seed spacing. Counter 20G (8.9 lb/A) was applied at planting and Lorsban (2 pt/A) was applied on June 11 for control of root maggot. Sequence (glyphosate + S-metolachlor, 2.5 pt/A) was applied on June 13 and 24) for control of weeds. Postemergence azoxystrobin was applied in a 7-inch band in 10 gallon/A using 4002 nozzles and 34 psi on June 17 (6 leaf stage, ~4.5 weeks after planting) or June 26 (10 leaf stage, ~6 weeks after planting). Cercospora leaf spot (CLS) was controlled by Minerva Duo (16 fl oz/A) on Aug 01 and Super Tin + Topsin M (6 + 10 oz/A) on Aug 21 applied in 20 gallons water/A at 100 psi.

MDFC site. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (40 kg ha^{-1}). The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 31 at 4.5-inch seed spacing. Roundup PowerMax (5.5 lb product ae/gallon) tank-mixed with Dual Magnum (0.5 pt/A) was applied on Jun 05 and a tank-mix of Roundup PowerMax (5.5 lb product ae/gallon), N-tense (10 oz/A), Outlook (12 oz/A) and Stinger (4 oz/A) was applied on Jul 02. Postemergence azoxystrobin was applied in a 7-inch band on June 18 (4-leaf stage, 2.5 weeks after planting) or July 01 (8-leaf stage, 4 weeks after planting). Cercospora leaf spot was controlled by application of Super Tin + ManKocide (8 oz/A+ 2.5 lbs/A) on Jul 12, Provysol + Badge SC (5 fl. Oz/A+2 pt/A) on Jul 24, Super Tin + Manzate (8 fl oz/A+1.5 qt/A on Aug 07, and Inspire + Badge SC (2 fl oz/A+2 pt/ A) on Aug 18. All fungicides for CLS control were applied utilizing a 3pt-mounted sprayer dispersing the products in broadcast pattern at a water volume of 15 GPA with TeeJet 8002 flat fan nozzles at 80 psi.

Table 1. Application type, product names, active ingredients, and rates of fungicides used at planting in a field trial for control of *Rhizoctonia solani* AG 2-2 on sugarbeet. Each at-plant treatment was used in combination with a Rhizoctonia resistant (2-year average rating = 3.9) and moderately susceptible (2-year average rating = 4.5) variety, and all treatment combinations in triplicate, with one set receiving a postemergence 7-inch band application of azoxystrobin (14.3 fl oz A^{-1}) at 4- or 8-leaf stage. Standard rates of Apron + Thiram and 45 g/unit Tachigaren were on all seed.

Application	Product	Active ingredient	Rate
None	-	-	-
Seed	Systiva	Fluxapyroxad	5 g a.i./unit seed
In-furrow	Quadris	Azoxystrobin	9.5 fl oz product A^{-1}

Table 2. Monthly precipitation in inches at three sites during 2019 crop season based on weather stations.

	Precipitation in inches		
Month	NWROC	MDFC	SMBSC
April	1.56	0.80	-
May	1.38	2.82	4.24
June	1.39	2.65	2.40
July	3.32	6.30	4.34
August	4.72	2.50	2.46
September	6.92	5.79	5.02
October	4.15	2.73	4.01
Total	**23.44**	**23.59**	**22.44**

SMBSC site. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (40 kg ha^{-1}). The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 14 at 4.77-inch seed spacing. Inoculum was incorporated using the 8.5 foot cultivator followed by the drag. Weeds were controlled by application of Roundup Powermax (32 oz/A) on Jun 10 followed by Roundup Powermax (22 oz/A) Jul 16. Postemergence azoxystrobin timings were applied on June 10 (4-leaf, ~3.5 weeks after planting), or June 19 (8-leaf, ~5 weeks after planting) as 7 inch bands using 4001E nozzles at 35 psi. Cercospora leaf spot was managed by fungicide application of Dithane on Jul 03, Inspire XT + Dithane on Jul 08, SuperTin + Dithane on Jul 18, Provysol + Champ on Jul 31, Agri-Tin + Dithane on Aug 09, Minerva + Badge on Aug 21, and Super Tin + Badge on Sept 09. All fungicides for CLS control were applied in a water volume of 19.3 GPA with 11002 nozzles at 70 psi.

At NWROC and MDFC stand counts were done beginning 2 weeks after planting through 7 weeks after planting. At SMBSC stand counts were done 1.5, 4, and 6.5 weeks after planting. The trial was harvested on Sept 18 at the NWROC, Oct 09 at Wahpeton and Sept 17 at Renville. Data were collected for number of harvested roots (NWROC only), yield, and quality. Twenty roots per plot also were arbitrarily selected and rated for severity of RCRR using a 0 to 7 scale (0 = healthy root, 7 = root completely rotted and foliage dead). Disease incidence was reported as the percent of rated roots with a root rot rating > 2.

Data were subjected to analysis of variance using SAS Proc GLM (SAS Institute, Cary, NC) for main effects of variety, at-plant treatment, postemergence azoxystrobin application, and all possible interactions. Means were separated by Fisher's Protected Least Significant Difference (*P* = 0.05).

RESULTS AND DISCUSSION

NWROC site: Early part of the 2019 growing season was dry at the NWROC during the period of May-June resulting in lower early season disease pressure. Rainfall at the NWROC was just 1.38 in. during the month of May and 1.39 in. during the month of June (Table 2) compared to a 30-year average of 2.83 and 4.05 in., respectively. Resistant (R) and moderately susceptible (MS) varieties had similar stands from 2 to 7 weeks after planting (WAP). Untreated and Systiva treatments had higher stands from 3 to 7 WAP compared to Systiva + Quadris in-furrow and Quadris in-furrow treatments (Fig. 1). Dry conditions during early season resulted in some stand reduction (12.6% reduction at 19 days after planting compared to untreated or Systiva treated seed) in treatments with Quadris in-furrow application at this site. Stand reduction with Quadris was also observed in 2017 and 2018 (4,5). Control plants had 182 plants/100 ft. row at 7 WAP indicating very low early season disease pressure. Slight to no root rot severity and incidence were observed for both varieties at harvest. Moderately susceptible variety had significantly higher percent sucrose, less loss to molasses, and higher recoverable sucrose T^{-1} (RST) (Table 3). There were no significant differences between Quadris I-F, Systiva, Systiva + Quadris I-F or control treatment for any harvest parameters. Both 4- and 8-leaf Quadris applications resulted in significant reduction in root rot rating and incidence (Table 3). However, there was no difference in yield, percent sucrose, recoverable sugar A^{-1} (RSA), or RST among treatments (Table 3). There was a significant at-planting by postemergence treatment interaction for root rot rating (Fig. 2); more impact of postemergence Quadris applications was observed on untreated seed or Systiva treated seed compared to treatments involving Quadris in-furrow application.

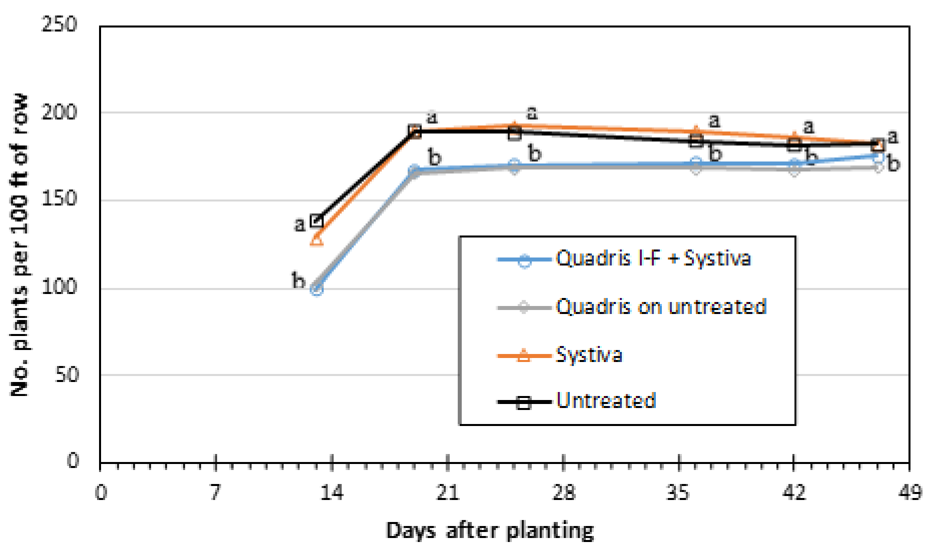

Fig. 1. NWROC site: Emergence and stand establishment for fungicide treatments at planting or untreated control. For each stand count date, values sharing the same letter are not significantly different (*P* = 0.05). Data shown represents mean of 24 plots averaged across varieties and postemergence treatments.

Table 3. NWROC site: Main effects of variety, at-planting, and postemergence fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in a field trial sown May 16, 2019.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft[T]	RCRR (0-7)[TU]	RCRR % incidence[TV]	Yield ton A^{-1}[T]	Sucrose[T] %	Sucrose[T] lb ton^{-1}	Sucrose[T] lb A^{-1}
Variety[W]							
Resistant	142	0.11	1.4	19.9	17.8	336	6690
Moderately Susceptible	154	0.11	1.8	21.0	18.1	344	7211
ANOVA p-value	0.155	0.768	0.308	0.395	**0.001**	**0.004**	0.245
At-planting treatments[X]							
Untreated control	154	0.12	1.9	20.7	17.9	337	6993
Systiva	153	0.20	3.1	19.6	18.1	343	6703
Quadris In-furrow	140	0.04	0.2	19.8	18.0	341	6755
Systiva + Quadris I-F	145	0.08	1.0	21.8	17.8	337	7350
ANOVA p-value	**0.046**	0.061	0.124	0.064	0.222	0.184	0.134
LSD (*P* = 0.05)	10.3	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]							
None	145	0.20 a	3.3 a	20.1	17.9	339	6820
4-leaf Quadris	151	0.07 b	0.8 b	20.8	17.9	339	7065
8-leaf Quadris	148	0.06 b	0.6 b	20.4	18.0	341	6966
ANOVA p-value	0.353	**<0.0001**	**0.001**	0.157	0.288	0.325	0.213
LSD (*P* = 0.05)	NS	0.06	1.5	NS	NS	NS	NS
Vty x at-palnt	NS	NS	NS	NS	NS	NS	NS
Vty x Post	NS	NS	NS	NS	NS	NS	NS
At-plant x Post	NS	**0.017**	NS	NS	NS	NS	NS
Vty x At-plant x Post	NS	NS	NS	NS	NS	NS	NS

[T]Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, *P* = 0.05; NS = not significantly different

[U]RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead

[V]RCRR = Rhizoctonia crown and root rot; percent of roots with rating greater than two

[W]Values represent mean of 48 plots (4 replicate plots across 4 at-planting treatments and 3 postemergence treatments)

[X]Systiva @ 5 g a.i /unit and Quadris In-furrow @ 9.5 fl oz./A via drip tube; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 postemergence treatments)

[Y]Quadris Postemergence @ 14.5 fl oz./A in a 7 inch band; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 at-planting treatments)

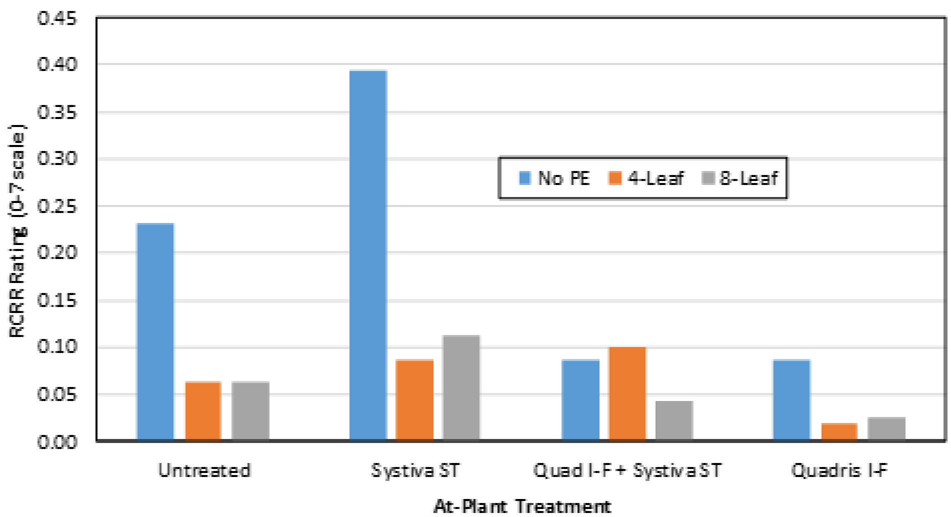

Fig. 2.NWROC site: Effect of at-panting and postemergence (PE) treatment interaction on Rhizoctonia root rot rating. Data shown represents mean of 8 plots averaged across varieties.

MDFC site: Late planting coupled with some moisture (Table 2) resulted in some early season disease pressure at this site. Resistant and moderately susceptible varieties had similar stands from 2 to 5.5 weeks after planting (WAP). Systiva and Systiva + Quadris I-F had significantly higher stands at 4 to 5 WAP compared to untreated control treatment (Fig. 3). At-plant control treatments had 180 plants/100 ft. row at 5.5 WAP indicating very low early season disease pressure at this site and yet Systiva had 201 and Systiva + Quadris had 216 plants/100 ft. row. Late planting (May 31) at this site did not result in stand reduction from Quadris in-furrow application (Fig. 3). However, Quadris in-furrow reduced stands at this site in 2018 (4). Even though July had substantial rainfall, relatively dry August resulted in low end-of the-season root rot development (Table 2). Resistant variety had significantly lower root rot rating and incidence, and lower purity compared to the moderately susceptible variety. Systiva + Quadris I-F had significantly lower root rot followed by untreated control and Systiva treatments (Table 4). No other harvest parameters were significantly different for at-planting treatments (Table 4). Postemergence Quadris application (4- or 8-leaf) significantly reduced root rot severity and incidence and increased yield and RSA compared to no postemergence application (Table 4). There was a significant variety x at-plant x postemergence treatment interaction for root rot rating (Figure 4). For the resistant variety, Quadris postemeregnce application may not be needed with Quadris I-F + Systiva, and 4- and 8-leaf Quadris postmeregence reduced root rot on untreated and Systiva treated seed with 8-leaf application resulting in slightly lower disease compared to 4-leaf post application. Whereas for the moderately susceptible variety, 4- or 8-leaf Quadris post reduced root rot with 4-leaf performing better on untreated and 8-leaf performing better on Quadris I-F + Systiva and Systiva treated seed (Figures 4A and 4B).

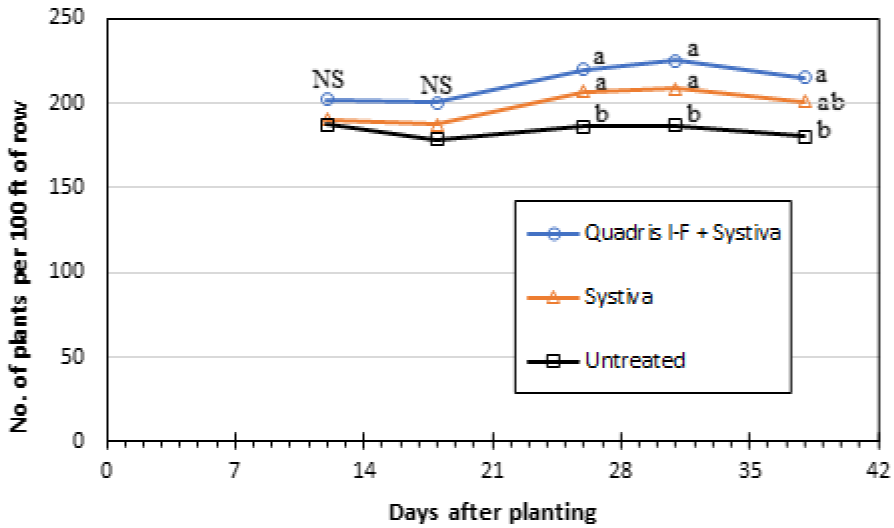

Fig. 3.MDFC site: Emergence and stand establishment for fungicide treatments at planting or untreated control. For each stand count date, values sharing the same letter are not significantly different (P = 0.05); NS = not significantly different. Data shown represents mean of 24 plots averaged across varieties and postemergence treatments.

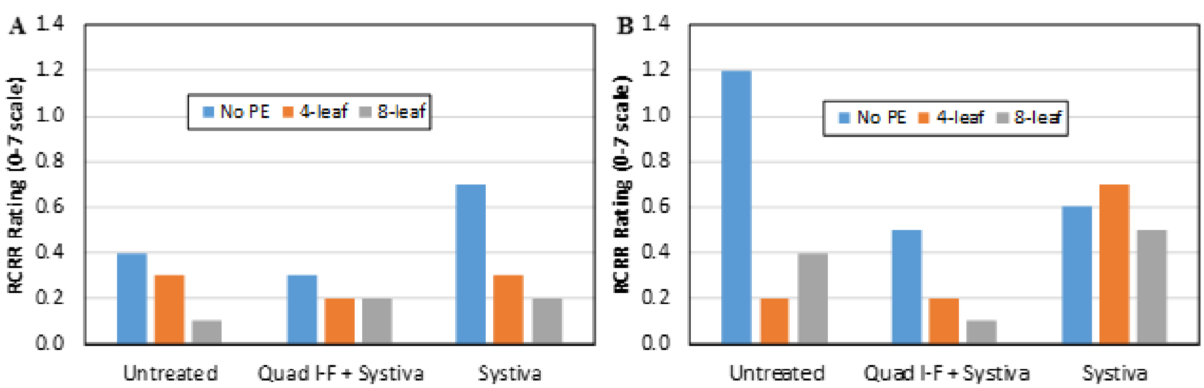

Fig. 4.MDFC site: Three way interaction of variety x at-plant x postemergence treatments for RCRR rating on the (A) resistant variety and (B) moderately susceptible variety. Data shown represents mean of 4 plots.

Table 4. MDFC site: Main effects of variety, at-planting, and postemergence fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in a field trial sown May 31, 2019.

Main effect	RCRR	RCRR %	Yield	Sucrose[T]		
(Apron + Maxim on all seed)	(0-7) [TU]	incidence[TV]	ton A^{-1T}	%	lb ton^{-1}	lb A^{-1}
Variety[W]						
Resistant	0.3	2.9	23.6	14.6	231	5434
Moderately Susceptible	0.5	9.0	22.3	14.8	238	5315
ANOVA p-value	**0.023**	**0.025**	0.391	0.434	0.246	0.658
At-planting treatments[X]						
Untreated control	0.4 ab	6.3	23.2	14.6	233	5405
Systiva	0.5 b	8.1	23.0	14.7	235	5395
Systiva + Quadris I-F	0.3 b	3.5	22.7	14.7	235	5324
ANOVA p-value	**0.033**	0.088	0.894	0.590	0.690	0.955
LSD (*P* = 0.05)	0.17	NS	NS	NS	NS	NS
Postemergence fungicide[Y]						
None	0.6 a	10.6 a	21.6 b	14.7	234	5053 b
4-leaf Quadris	0.3 b	4.2 b	24.0 a	14.7	236	5628 a
8-leaf Quadris	0.3 b	3.1 b	23.3 a	14.7	234	5442 a
ANOVA p-value	**<0.0001**	**0.0004**	**0.0006**	0.774	0.869	**0.0008**
LSD (*P* = 0.05)	.016	3.7	1.1	NS	NS	285
Vty x At-plant	NS	NS	NS	NS	NS	NS
Vty x Post	NS	NS	NS	NS	NS	NS
At-plant x Post	NS	NS	NS	NS	NS	NS
Vty x At-plant x Post	**0.022**	NS	NS	NS	NS	NS

[T]Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, *P* = 0.05; NS = not significantly different

[U]RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead

[V]RCRR = Rhizoctonia crown and root rot; percent of roots with rating greater than two

[W]Values represent mean of 36 plots (4 replicate plots across 3 at-planting treatments and 3 postemergence treatments)

[X]Systiva @ 5 g a.i /unit and Quadris In-furrow @ 9.5 fl oz./A via drip tube; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 postemergence treatments)

[Y]Quadris Postemergence @ 14.5 fl oz./A in a 7 inch band; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 at-planting treatments)

SMBSC site: Low rainfall during June only resulted in slight disease pressure early in the season (Table 2). Resistant variety had higher stands at 2, 4, and 6 WAP compared to moderately susceptible variety (Fig. 5). Systiva and Systiva + Quadris I-F had highest stands at 2, 4, and 6 WAP compared to untreated control treatment. Untreated control had 213 plants/100 ft. row at 7 WAP indicating very low early season disease pressure at this site and hence Systiva and Systiva + Quadris I-F had 222 and 225 plants/100 ft. row, respectively (Fig. 6). In contrary to 2018 observations (4), Quadris I-F did not reduce stands at this site in 2019. Less than normal rainfall during July and some rainfall in Aug (Table 2) resulted in some late season disease pressure at this site. Variety by postemergence interaction was observed for number of harvested roots, root rot rating, incidence, yield and RST (Table 5); (i) postemergence application had significant benefit on the moderately susceptible variety (ii) Both 4- and 8-leaf application were effective on resistant variety, while on the moderately susceptible variety most benefit was seen with the 8-leaf postemergence application (Figs. 7A, 7B and 7C). At-panting by postemergence interaction on yield was observed (Table 5); postemergence applications significantly improved yield parameters in treatments with no Quadris in-furrow application (Fig 8) and 4-leaf Quadris application looked better on untreated and Systiva treated seed compared to 8-leaf application on

Table 5. SMBSC site: Main effects of variety, at-planting, and postemergence fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in a field trial sown May 14, 2019.

Main effect (Apron + Maxim on all seed)	RCRR (0-7) [TU]	RCRR % incidence[TV]	Yield ton A^{-1} [T]	Sucrose[T] %	Sucrose[T] lb ton^{-1}	Sucrose[T] lb A^{-1}
Variety[W]						
Resistant	0.3	5.8	26.9	15.7	256	6886
Moderately Susceptible	0.8	17.1	27.6	15.8	263	7243
ANOVA p-value	**0.005**	**0.001**	0.465	0.578	0.166	0.095
At-planting treatments[X]						
Untreated control	0.6	13.3	27.0	15.5	253	6842
Systiva	0.7	13.5	26.9	16.0	266	7160
Systiva + Quadris I-F	0.4	7.5	27.8	15.7	259	7191
ANOVA p-value	0.085	0.090	0.099	0.183	0.299	0.291
LSD (*P* = 0.05)	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]						
None	1.1 a	23.5 a	26.2 b	15.3 b	247 b	6468 b
4-leaf Quadris	0.4 b	8.5 b	27.9 a	15.9 a	265 a	7384 a
8-leaf Quadris	0.1 c	2.3 c	27.6 a	16.0 a	266 a	7341 a
ANOVA p-value	<0.0001	<0.0001	<0.0001	0.0004	0.001	<0.0001
LSD (*P* = 0.05)	0.24	4.9	0.65	0.31	10.8	288
Vty x at-plant	NS	NS	NS	NS	NS	NS
Vty x Post	**0.022**	**0.015**	**0.008**	NS	**0.041**	NS
At-plant x Post	NS	NS	**0.031**	NS	NS	NS
Vty x at-plant x Post	NS	NS	NS	NS	NS	NS

[T]Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, *P* = 0.05; NS = not significantly different

[U]RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead

[V]RCRR = Rhizoctonia crown and root rot; percent of roots with rating greater than two

[W]Values represent mean of 36 plots (4 replicate plots across 3 at-planting treatments and 3 postemergence treatments)

[X]Systiva @ 5 g a.i /unit and Quadris In-furrow @ 9.5 fl oz./A via drip tube; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 postemergence treatments)

[Y]Quadris Postemergence @ 14.5 fl oz./A in a 7 inch band; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 at-planting treatments)

Quadris I-F + Systiva seed (Fig. 8). Variety by at-plant by postemergence interaction was observed for no. of harvested roots (Table 5); postemergence application resulted in higher no. of harvested roots for Quadris I-F + Systiva and untreated control treatments for the moderately susceptible variety, but this trend was not observed for the resistant variety. Similar benefit from postemergence Quadris application at this location was also evident in 2016 thru 2018 (4-6). This clearly demonstrates the importance of choosing a resistant variety for managing Rhizoctonia diseases. In fields with heavy Rhizoctonia pressure, Quadris in-furrow application on treated seed will provide better protection compared to seed treatment only as observed in this trial especially when using a susceptible variety for Rhizoctonia.

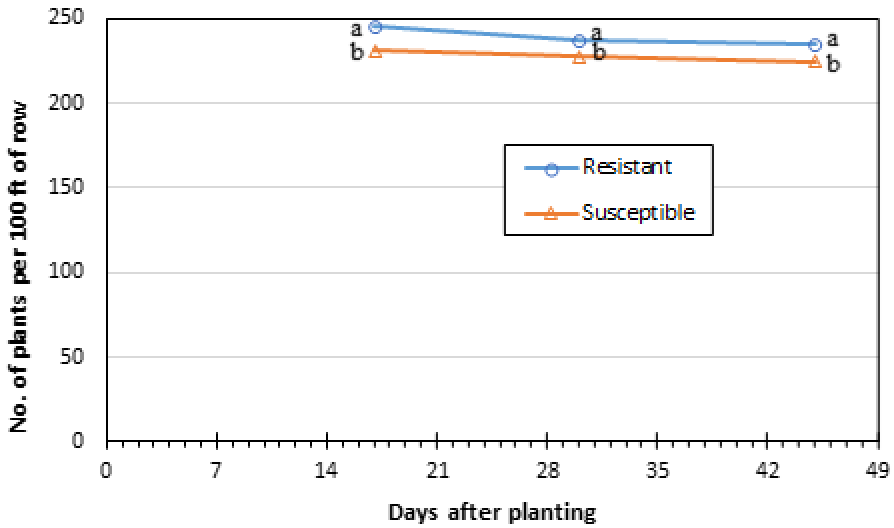

Fig. 5.SMBSC site: Emergence and stand establishment for resistant and moderately susceptible varieties. For each stand count date, values sharing the same letter are not significantly different (*P* = 0.05). Data shown represents mean of 36 plots averaged across at-planting and postemergence treatments.

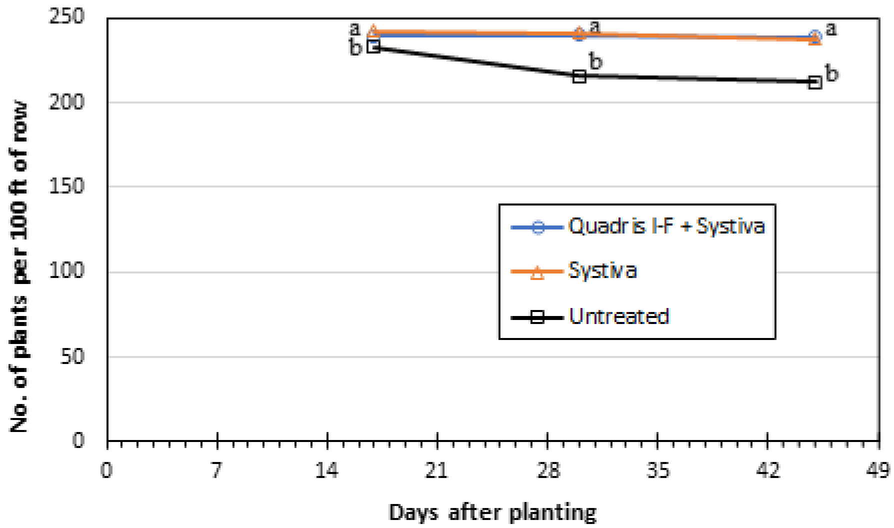

Fig. 6. SMBSC site: Emergence and stand establishment for the at-planting treatments. For each stand count date, values sharing the same letter are not significantly different (*P* = 0.05). Data shown represents mean of 24 plots averaged across varieties and postemergence treatments.

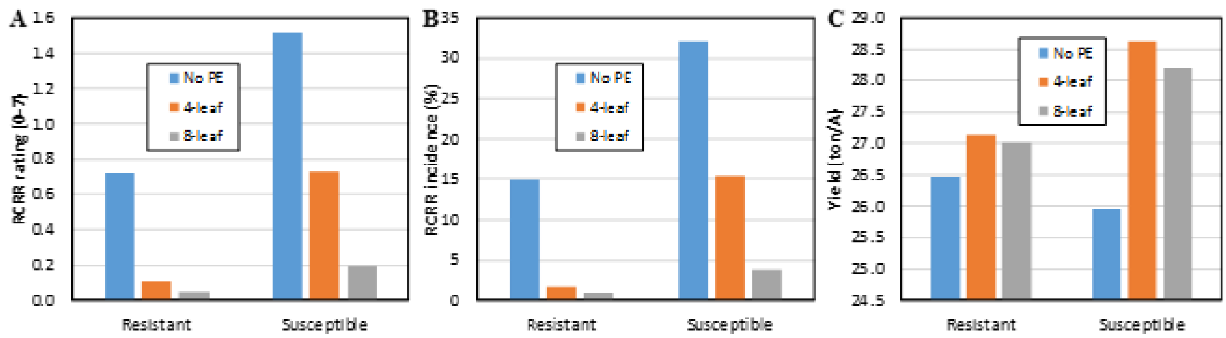

Fig. 7. SMBSC site: Effect of variety and postemergence treatments on **A)** RCRR rating (0 to 7 scale, 0 = root clean, no disease, 7 = root completely rotted and plant dead), **B)** RCRR incidence (% roots with rating > 2) and **C)** yield. Data shown represents mean of 12 plots averaged across at-planting treatments.

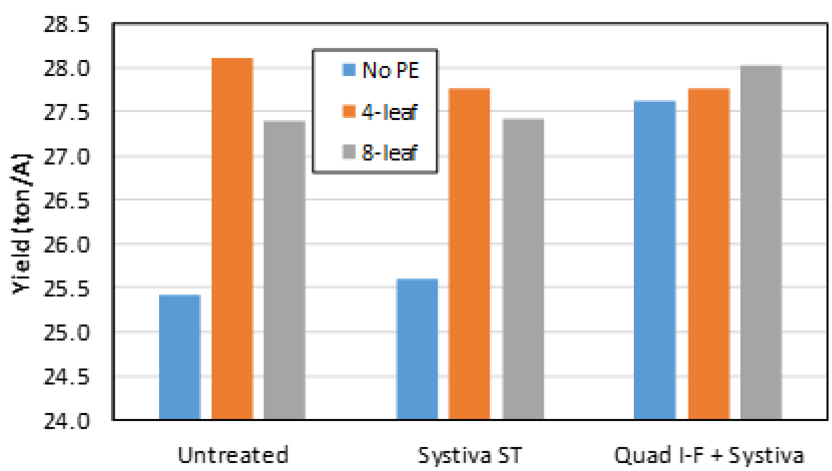

Fig. 8. SMBSC site: Effect of at-planting and postemergence treatments on root yield. Data shown represents mean of 8 plots averaged across varieties.

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References

1. Brantner, J.R. 2019. Plant pathology laboratory: summary of 2017-2018 field samples. 2018 Sugarbeet Res. Ext. Rept. 49:202-203.
2. Brantner, J.R. and Chanda, A.K. 2017. Plant pathology laboratory: summary of 2015-2016 field samples. 2016 Sugarbeet Res. Ext. Rept. 41:260-261.
3. Brantner, J.R., H.R. Mickelson, and E.A. Crane. 2014. Effect of *Rhizoctonia solani* inoculum density and sugarbeet variety susceptibility on disease onset and development. 2013 Sugarbeet Res. Ext. Rept. 44:203-208.
4. Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Mettler, D. 2019. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2018 Sugarbeet Res. Ext. Rept. 49:166-175.
5. Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Groen, C. 2018. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2017 Sugarbeet Res. Ext. Rept. 48:129-136.
6. Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Groen, C. 2017. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2016 Sugarbeet Res. Ext. Rept. 47:174-179.
7. Niehaus, W.S. 2019. Results of American Crystal's 2018 Official Coded Variety Trials. 2018 Sugarbeet Res. Ext. Rept. 49:206-263.

EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET

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Rhizoctonia damping-off and crown and root rot (RCRR) caused by *Rhizoctonia solani* AG 2-2 have been the most common root diseases on sugarbeet in Minnesota and North Dakota for several years (2-4, 6,7, 11). Disease can occur throughout the growing season and reduce plant stand, root yield, and quality (5). Warm and wet soil conditions favor infection. Disease management options include rotating with non-host crops (cereals), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), and/or postemergence. An integrated management strategy should take advantage of multiple control options to reduce Rhizoctonia crown and root rot (5).

OBJECTIVES

A field trial was established to evaluate various at-planting fungicide treatments (seed treatment and in-furrow) for 1) control of early-season damping-off and RCRR and 2) effect on plant stand, yield and quality of sugarbeet.

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 572RR) with a 2-year average Rhizoctonia rating of 4.5 (13) was used. Treatments were arranged in a randomized complete block design with four replicates. Seed treatments and rates are summarized in Table 1 and were applied by Germains Seed Technology, Fargo, ND. In-furrow fungicides (Table 1) (in 3 gal water) and starter fertilizer (3 gallons 10-34-0) were applied down the drip tube in 6 gallons total volume A^{-1}. The untreated control included no Rhizoctonia active seed or in-furrow fungicide treatment at planting. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (40 kg/ha) by hand-broadcasting in plots, and incorporating with a Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 25-ft rows) on May 15 at 4.5-inch seed spacing. Counter 20G (8.9 lb A^{-1}) was applied at planting and Lorsban (2 pt A^{-1}) was applied June 11 for control of sugarbeet root maggot. Glyphosate (4.5 lb product ae/gallon) was applied on June 4 (22 oz/A) and June 24 (28 oz/A) and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) was applied on June 13 for control of weeds. Cercospora leafspot was controlled by Minerva Duo (16 fl oz/A) on August 1 and Supertin + Topsin M (6 + 10 oz/A) on August 21 applied in 20 gallons water/A at 100 psi.

Stand counts were done beginning ~2 weeks after planting through 7 weeks after planting. The trial was harvested on September 19. Data were collected for number of harvested roots, yield, and quality. Twenty roots per plot also were arbitrarily selected and rated for severity of RCRR using a 0 to 7 scale (0 = healthy root, 7 = root completely rotted and foliage dead). Disease incidence was reported as the percent of rated roots with a root rot rating > 2. Data were subjected to analysis of variance using SAS Proc GLM (SAS Institute, Cary, NC). Treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. Orthogonal contrasts were used to compare seed treatment versus in-furrow fungicides and seed treatment and in-furrow fungicides versus the untreated control.

Table 1. Application type, product names, active ingredients, and rates of fungicides used at planting in a field trial for control of *Rhizoctonia solani* AG 2-2 on sugarbeet. Standard rates of Allegiance + Thiram and 45 g/unit Tachigaren were on all seed. In-furrow fungicides in 3 gal water mixed with 3 gal 10-34-0 were applied down the drip tube in a total volume of 6 gal/A.

Application	Product	Active ingredient	Rate[Y]
None	-	-	-
Seed	Kabina ST	Penthiopyrad	14 g a.i./unit seed
Seed	Metlock Suite + Kabina ST	Metconazole + Rizolex + Penthiopyrad	0.21 + 0.5 + 7 g a.i./unit seed
Seed	Metlock Suite + Vibrance	Metconazole + Rizolex + Sedaxane	0.21 + 0.5 + 1.0 g a.i./unit seed
Seed	Systiva	Fluxapyroxad	5 g a.i./unit seed
Seed	Vibrance	Sedaxane	1.5 g a.i./unit seed
Seed + in-furrow	Kabina ST + Quadris	Penthiopyrad + azoxystrobin	14 g a.i./unit + *6 fl oz prod A^{-1}
In-furrow	AZteroid	Azoxystrobin	5.7 fl oz product A^{-1}
In-furrow	Quadris	Azoxystrobin	9.5 fl oz product A^{-1}
In-furrow	Xanthion	Pyraclostrobin + *Bacillus amyloliquefaciens*	9.0 + 1.8 fl oz product A^{-1}
In-furrow	Elatus[Z]	Azoxystrobin + Benzovindiflupyr	7.1 oz product A^{-1}
In-furrow	Proline	Prothioconazole	5.7 fl oz product A^{-1}
In-furrow	Propulse	Fluopyram + prothioconazole	13.6 fl oz product A^{-1}

[Y]5.7 fl oz AZteroid, 6 and 9.5 fl oz Quadris contain 67, 44 and 70 g azoxystrobin, respectively; 9 + 1.8 fl oz Xanthion contains 67 g pyraclostrobin + ~1.2 x 10^{12} viable spores of *Bacillus amyloliquefaciens* strain MBI 600; 7.1 oz Elatus contains 61 g azoxystrobin and 30 g benzovindiflupyr; 5.7 fl oz proline contains 81 g prothioconazole; 13.6 fl oz Propulse contains 80 g each of fluopyram and prothioconazole

[Z] Elatus is not currently registered for use on sugarbeet

*Quadris rate is less than minimum labeled rate of 9.5 fl. oz product/A, only included for research purpose

RESULTS AND DISCUSSION

Emergence in plots with Rhizoctonia seed treatment fungicides was similar to the untreated control. By 3 weeks after planting, emergence was mostly completed and stands were greater than 200 plants per 100 ft of row (Fig. 1). Emergence in plots with in-furrow fungicides was reduced compared with the seed treatments and untreated control with just over 180 plants per 100 ft of row at 3 weeks after planting (Fig. 1). Stand was significantly lower during the 7-week stand count period for in-furrow treatments compared with seed treatments. It is not unusual for stand establishment to be reduced for in-furrow fungicides compared to seed treatments at this location if planting is followed by dry conditions. After 3 weeks, stand remained steady for plots with seed treatment or in-furrow fungicides, but declined slightly in the untreated control plots, indicating very low disease pressure from *R. solani*. Lack of disease pressure during the period after emergence when seedlings are very susceptible to Rhizoctonia damping-off was likely due to low soil moisture. Rainfall at the NWROC for the months of May and June was 1.38 and 1.39 inches, respectively, compared to 30-year averages of 2.83 and 4.05 inches for the same months. Stand establishment at 7 weeks after planting for individual treatments is shown in Table 2. Stand was highest for plots with seed treatment fungicides and the untreated control, lowest for plots receiving AZteroid or Quadris in-furrow, and intermediate for plots with Kabina ST plus the 6 fl oz rate of Quadris and plots receiving Xanthion, Elatus, Proline, or Propulse in-furrow (Table 2). It appears that the lower rate of Quadris with an effective Rhizoctonia seed treatment may be a possible way to reduce stand loss. However, the efficacy of this treatment combination could not be evaluated in this trial because of lack of disease pressure. It is also important to know that certain isolates of *R. solani* AG 2-2 have low sensitivity to Quadris on artificial media (1,13), and still can be managed with labeled field rates of Quadris under greenhouse conditions (1).

Rainfall was much higher during the months of July through September but disease pressure remained low and variable throughout the trial area. The number of harvested roots was not significantly different among treatments (Table 2). Rhizoctonia crown and root rot ratings and incidence were significantly lower for in-furrow treatments compared to seed treatments (Table 2). Among individual treatments, all seed treatments were statistically similar to the untreated control while all in-furrow fungicides except Proline had lower disease ratings and incidence compared to the untreated control (Table 2). Root and sucrose yields were not significantly different among treatments. Root yields ranged from 22.4 to 25.4 ton A^{-1} and percent sucrose ranged from 17.2 to 18.0 %. Lack of significant differences for root and sucrose yield in 2019 is similar to 2017 and 2018 when late-season disease pressure was low but in contrast with typical years with higher disease pressure, where in-furrow fungicides resulted in lower root rot ratings and higher yields at harvest compared to seed treatments (8-10).

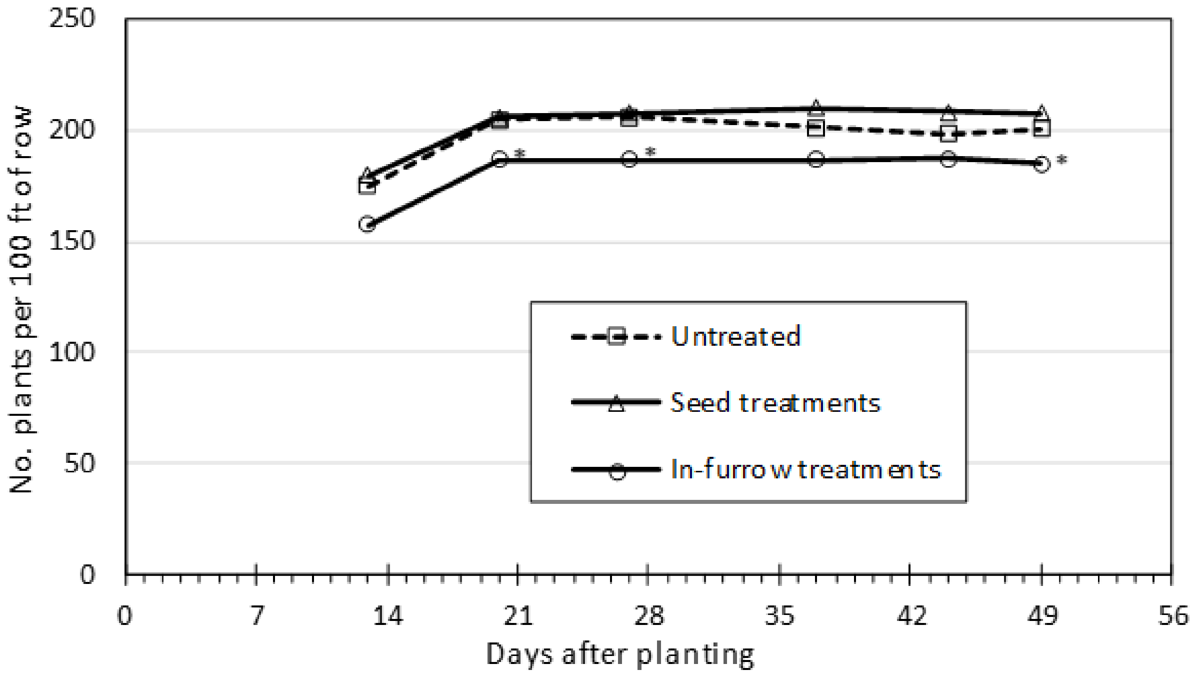

Fig. 1. Emergence and stand establishment for seed treatment and in-furrow fungicides compared to an untreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2. For each stand count date, symbols marked with an asterisk indicate stands significantly (P = 0.05) different than the untreated control (dotted line).

Table 2. Effects of at-planting (seed treatment or in-furrow) fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in a *Rhizoctonia*-infested field trial at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment	7-wk stand Plants/100 ft[V]	No. harv. Roots/100 ft[V]	RCRR (0-7)[VW]	RCRR % incidence[VX]	Yield[V]	Sucrose[V] %	Sucrose[V] lb ton^{-1}	Sucrose[V] lb A^{-1}
Untreated control	201 abcd	168	1.6	35	23.7	17.2	322	7640
Kabina ST	212 ab	189	1.3	30	23.1	17.5	330	7630
Met. Suite + 7 g Kabina	218 a	181	1.6	38	24.1	17.6	331	7999
Met. Suite + 1 g Vibrance	202 abcd	167	1.2	29	22.5	17.4	325	7305
Systiva	207 abc	176	1.9	39	22.7	17.4	328	7459
Vibrance	201 abcd	181	1.1	24	25.4	17.4	328	8349
Kabina ST + *Quadris I-F 6 oz I-F	195 bcde	177	0.5	10	23.5	18.0	341	8023
AZteroid in-furrow	176 e	160	0.5	10	24.3	17.9	338	8209
Quadris in-furrow	177 e	155	0.4	9	22.4	17.6	331	7421
Xanthion in-furrow	195 bcde	168	0.7	15	23.1	17.3	323	7462
Elatus in-furrow [Y]	193 cde	172	0.5	13	25.4	17.8	335	8508
Proline in-furrow	186 de	168	1.3	29	24.9	17.3	325	8096
Propulse in-furrow	184 de	159	0.3	10	22.5	17.3	324	7267
ANOVA P-value	0.0012	0.3679	0.0002	<0.0001	0.5026	0.4473	0.3846	0.3722
LSD (*P* = 0.05)	19.2	NS	0.7	14.9	NS	NS	NS	NS
Contrast analysis[Z]								
Seed vs in-furrow								
Mean of Seed trts.	208	177	1.4	32	23.6	17.5	329	7748
Mean of In-furrow trts.	185	163	0.6	14	23.8	17.5	329	7827
P-value	<0.0001	0.0183	<0.0001	<0.0001	0.7623	0.7095	0.8143	0.7438

[V]Values represent mean of 4 plots, values within a column followed by same letter(s) are not statistically significant at *P* = 0.05, NS = not significantly different

[W]RCRR = Rhizoctonia crown and root rot; 0-7 scale, 0 = root clean, no disease, 7 = root completely rotted and plant dead

[X]RCRR = Rhizoctonia crown and root rot; percent of roots with rating > 2

[Y]Elatus is not currently registered for use on sugarbeet

[Z]Contrast analysis of seed versus in-furrow fungicides does not include untreated control or treatment with both Kabina ST and Quadris in-furrow

* Quadris rate is less than minimum labeled rate of 9.5 fl. oz product/A, only included for research purpose

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References

1. Arabiat, S., and Khan, M. F. R. 2016. Sensitivity of *Rhizoctonia solani AG-2-2 from Sugar Beet to Fungicides. Plant Dis. 100:2427–2433.*

2. Brantner, J.R. and Chanda, A.K. 2019. Plant Pathology Laboratory: Summary of 2017-2018 Field Samples. 2018 Sugarbeet Res. Ext. Rept. 49:202-203.

3. Brantner, J.R. and A.K. Chanda. 2017. Plant pathology laboratory: summary of 2015-2016 field samples. 2016 Sugarbeet Res. Ext. Rept. 47:203-204.

4. Brantner, J.R. 2015. Plant pathology laboratory: summary of 2013-2014 field samples. 2014 Sugarbeet Res. Ext. Rept. 45:138-139.

5. Brantner, J.R. and A.K. Chanda. 2015. Integrated management of Rhizoctonia on sugarbeet with varietal resistance, seed treatment, and postemergence fungicides. 2014 Sugarbeet Res. Ext. Rept. 45: 142-146

6. Brantner, J.R. and C.E. Windels. 2011. Plant pathology laboratory: summary of 2009-2010 field samples. 2010 Sugarbeet Res. Ext. Rept. 41:260-261.

7. Brantner, J.R. and C.E. Windels. 2009. Plant pathology laboratory: summary of 2007-2008 field samples. 2008 Sugarbeet Res. Ext. Rept. 39:250-251.

8. Brantner, J.R. and Chanda, A.K. 2019. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. 2018 Sugarbeet Res. Ext. Rept. 49:176-179.

9. Chanda, A.K. and J.R. Brantner. 2017. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. 2016 Sugarbeet Res. Ext. Rept. 47:166-168.

10. Chanda, A.K. and J.R. Brantner. 2016. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia Solani*. 2015 Sugarbeet Res. Ext. Rept. 46:151-153.

11. Crane, E., Brantner, J.R., and Windels, C.E. 2013. Plant pathology laboratory: summary of 2011-2012 field samples. 2012 Sugarbeet Res. Ext. Rept. 43:169-170.

12. Sharma, P., Malvick, D. K. and Chanda, A. K. 2019. Sensitivity of *Rhizoctonia solani* isolates from soybean and sugar beet to selected SDHI and QoI fungicides. 2019 American Phytopathological Society Meeting Abstract, Cleveland, OH.

13. Niehaus, W.S. and Moomjian, D.L. 2019. Results of American Crystal’s 2018 official coded variety trials. 2018 Sugarbeet Res. Ext. Rept. 49:206-263.

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2019

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Leaf spot, caused by the fungus *Cercospora beticola*, is an endemic disease of sugarbeet produced in the Northern Great Plains area of North Dakota and Minnesota that reduces both yield and sucrose content. The disease is controlled by crop rotation, resistant varieties and timely fungicide applications. *Cercospora* leaf spot usually appears in the last half of the growing season, and multiple fungicide applications are necessary for disease management. Fungicides are used at high label rates and are alternated for best efficacy, but in recent years, mixtures are becoming more important. The most frequently used fungicides are Tin (fentin hydroxide), Topsin (thiophanate methyl), Eminent (tetraconazole), Proline (prothioconazole), Inspire (difenoconazole), and Headline (pyraclostrobin). Provysol (mefentrifluconazole) was registered for use on limited acreage in 2109. In 2019, most of the DMI and QoI fungicides were applied as mixtures with either mancozeb or copper and Topsin is usually applied as a tank mix with Tin.

Like many other fungi, *C. beticola* has the ability to become less sensitive (resistant) to the fungicides used to control them after repeated exposure, and increased disease losses can result. Because both *C. beticola* and the fungicides used for management have histories of fungicide resistance in our production areas and other production areas in the US, Europe and Chile, it is important to monitor our *C. beticola* population for changes in sensitivity to the fungicides in order to achieve maximum disease control. We have monitored fungicide sensitivity of field isolates of *C. beticola* collected from fields representing the sugarbeet production area of the Red River Valley region to the commonly used fungicides in our area annually since 2003. In 2098, extensive sensitivity monitoring was conducted for Tin, Topsin, Eminent, Inspire, Proline, Provysol and Headline.

OBJECTIVES

1) Monitor sensitivity of *Cercospora beticola* isolates to Tin (fentin hydroxide)

2) Monitor sensitivity of *Cercospora beticola* isolates to Topsin (thiophanate methyl) using PCR to detect the E198A mutationi

3) Monitor sensitivity of *Cercospora beticola* to four triazole (DMI) fungicides: Eminent (tetraconazole) and Inspire (difenoconazole) and Proline (prothioconazole) and Provysol (mefentrifluconazole)

4) Monitor *Cercospora beticola* isolates for the presence of the G143A mutation that confers resistance to Headline (pyraclostrobin) fungicide

5) Distribute results of sensitivity monitoring in a timely manner to the sugarbeet industry in order to make fungicide recommendations for disease management and fungicide resistance management for Cercospora leaf spot disease in our region.

METHODS AND MATERIALS

In 2019, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested 1230 *C. beticola* field isolates collected from throughout the sugarbeet production regions of ND and MN for sensitivity testing to Tin, Topsin, Eminent, Inspire, Proline, Provysol and Headline. For this report we use the commercial name of the fungicides, but all testing was conducted using the technical grade active ingredient of each fungicide, not the formulated commercial fungicide. The term µg/ml is equivalent to ppm.

Sugarbeet leaves with Cercospora leaf spot (CLS) are collected from commercial sugarbeet fields by agronomists from American Crystal Sugar Company, Minn-Dak Farmers Cooperative and Southern Minnesota Beet Sugar Cooperative representing all production areas in ND and MN and delivered to our lab for processing. From each field sample, *C. beticola* spores were collected from a minimum of five spots per leaf from five leaves and mixed to make a composite of approximately 2500 spores.

For Tin testing, a subsample of the spore composite was transferred to a Petri plate containing water agar amended with Tin at 1 ug/ml. Germination of 100 spores on the Tin amended water agar plates were counted 16 hours later and percent germination calculated. Germinated spores are considered resistant.

For Topsin testing, a PCR based molecular procedure was used to test for the presence of the E198A mutation in *C. beticola* that imparts resistance to Topsin. This is the second year the PCR test was used for testing for Topsin resistance and replaces the spore germination test.

For triazole fungicide sensitivity testing, a radial growth procedure is used. A single spore subculture from the spore composite is grown on water agar medium amended with serial ten-fold dilutions of each technical grade triazole fungicide from 0.01 – 100 ppm. A separate test is conducted for each triazole fungicide. After 15 days, inhibition of radial growth is measured, and compared to the growth of *C. beticola* on non-amended water agar medium. This data is used to calculate an EC_{50} value for each isolate; EC_{50} is a standardized method of measuring fungicide resistance and is calculated by comparing the concentration of fungicide that reduces radial growth of *C. beticola* by 50% compared to the growth on non-amended media. Higher EC_{50} values mean reduced sensitivity to the fungicide. An RF (resistance factor) is calculated for each DMI fungicide by dividing the EC_{50} value by the baseline value so fungicides can be directly compared. Beginning in 2016, RF value calculations were increased to 10 ppm and in 2019 were increased to100 ppm to accommodate increased number of isolates with resistance to the DMI fungicides higher than 10 ppm.

For Headline resistance testing a PCR based molecular procedure was used to test for the presence of a specific mutation in *C. beticola* that imparts resistance to Headline. This procedure detects a specific mutation, G143A, which results in complete resistance to Headline. DNA is extracted from the remaining spore composite and tested by real-time PCR using primers specific for the G143A mutation. The test enables us to estimate the percentage of spores with the G143A mutation in each sample. The results are placed in five categories based on an estimate of the percentage of spores with the G143A mutation: S = no spores with G143A; S/r = <50 of the spores with G143A; S/R = equal number of spores with G143A; R/s >50% of the spores with G143A; and R = all spores with G143A**.**Each sample tested contains approximately 2500-5000 spores and the DNA from this spore pool will test for the G143A mutation from each spore. The PCR test is more sensitive and requires less interpretation than the previously used spore germination test. The PCR test will estimate the incidence of resistance in the population of spores tested, and give a better indication of Headline resistance in a field.

RESULTS AND DISCUSSION

CLS pressure was moderate in most locations in 2019, but cool temperatures and disastrous wet weather likely reduced disease pressure at the end of the season, especially in northern production areas. Disease pressure continued to be high in southern production areas. The majority of the CLS samples were delivered to our lab at the end of the season in late September and early October. Field samples (n=1097) representing all production areas and factory districts were tested for sensitivity to even fungicides: fentin hydroxide (Tin), thiophanate methyl (Topsin), tetraconazole (Eminent), difenoconazole (the most active part of Inspire), prothioconazole (Proline), mefentrifluconazole (Provysol) and pyraclostrobin (Headline). One additional DMI fungicide not registered in the US for CLS were tested for activity against *C. beticola*.

TIN. Tolerance (resistance) to Tin was first reported in 1994 at concentrations of 1-2 µg/ml. At these levels, disease control in the field is reduced. The incidence of fields with isolates resistant to Tin at 1.0 µg/ml increased between 1997 and 1999, but the incidence of fields with resistant isolates has been declining since the introduction of additional fungicides for resistance management, including Eminent in 1999, Gem in 2002 and Headline in 2003. In 1998, the incidence of fields with isolates resistant to Tin at 1.0 µg/ml was 64.6%, and declined to less than 10% from 2002 to 2010. From 2011 to 2014 there was an increase in the number of fields with resistance **(Figure 1),** and from 2015 to 2017, the incidence of fields with isolates resistant to Tin increased from 38.5% to 97% (**Figure 1**). In 2018, the incidence of fields with isolates resistant to tin declined to 65.2% and declined again to 21.3% in 2019 (**Figure 1**). The severity of resistance, as expressed as percent germination of spores from fields with resistant isolates, ranged from 1 to 100%, with the average germination rate ranging from 16 to 28% during the five year period of 2013 to 2017 **(Figure 1)**. In 2018, spore germination declined to 15.5% and to 28.0 % in 2019. The incidence of fields with tin resistance declined dramatically in all factory districts except Moorhead and

SMBSC (**Figure. 2**). The low severity of resistance (21.0 %) may be the reason that tin is still an effective fungicide for managing CLS despite widespread incidence of resistance to tin.

TOPSIN. Resistance to Topsin has been present in our area since 1999, and is also common and widespread in European Union production areas. Resistance has historically been >70% of the fields tested, but declined below that level in six years since 1999 (**Figure 3).** Topsin resistance, in sugarbeet and other crops, tends to decline when it is not used, but reappears quickly when it is again used in the field. Since 2013, the incidence of field with Topsin resistance was >70% (**Figure 3**). The incidence of fields with Topsin resistance in 201 increased to 88.6% and to 98.2% in 2019 (**Figure 3**). Data from 2018 and 2019 based on PCR testing for the E198A mutation. The severity of resistance, as expressed as percent germination of spores from fields with resistant isolates ranged from 1 to 100%, with the average germination rate of 25% in 2017. We were not able to test severity of resistance in 2018 and 2019 using the PCR test. Most applications of Topsin are as tank mixtures with Tin, which seems to be an effective management practice.

DMI (triazoles). Resistance as measured by RF values increased in 2019 for Inspire, Eminent and Provysol (**Figure 4**), but testing was extended to 100 ppm which may account for the increase. Isolates with RF values >100 ppm were detected for all four DMI fungicides (**Figure 5**), indicating increased resistance levels. Resistance was found in all factory districts, but there was some variability (**Figure 6**). RF values for Proline were low, but this was likely to using prothioconazole for testing instead of the active metabolic product desthioconazole for testing. Regardless, sensitivity to Proline was similar across all factory districts.

HEADLINE. Beginning in 2012, a PCR based molecular procedure was used to test for the presence of the G143A mutation in *C. beticola* using a composite spore sample containing approximately 2500-5000 spores. The presence of this mutation indicates absolute resistance to Headline. The G143A mutation was first detected in the RRV production area in 2012 and increased from 2013 to 2015. Resistance to Headline increased dramatically from 2016 to 2019 (**Figure 7**) and across all factory districts. In 2019, resistance to Headline continued to be at high levels similar to 2017 and 2018; resistance did not decline (**Figure 7**). (**Figure 7)**. Resistance was found at high levels in all factory districts, but resistance levels declined in the Minn-Dak factory district (**Figure 8**). This is a trend we hope continues, as we do not know if this mutation has the ability to revert to the sensitive wild type or not. We will continue to monitor for resistance to Headline in the RRV production area, particularly because Headline is often the only fungicide used, and is used annually even in the absence of disease. We do not know if there is a fitness penalty associated with the G143A mutation, but based on observation in MI and Italy, Austria and Serbia, where QoI resistance due to the G143A mutation is widespread. it appears that isolates with the G143A mutation are stable and can survive and increase in the population.

SUMMARY

1. Resistance to Tin at 1.0 µg/ml almost disappeared in our region from 2003-2010, but has increased since 2011, probably due to increased use. In 2019, the number of fields with tin resistance declined 36% and 65% in the past two years. The percentage of spores with resistance/field was stable at about 28 %. Efforts should continue to preserve this fungicide for Cls management. .

2. Resistance to Topsin continues to be present in our region at high levels. Topsin resistance was present in 98,2% of the isolates collected in 2019 using PCR testing for the E198A mutation that imparts resistance to Topsin. Topsin resistance remains in the population and Topsin is not an important resistance management partner. Topsin resistance was found in all factory districts.

3. This is where the action is. We now have four DMI fungicides available: Eminent, Proline, Inspire and Provysol. Resistance factors continue to increase for Eminent, Inspire and Provysol. Some isolates have RF levels >100 ppm, which is very high. Resistance to DMI fungicides is present in all factory districts with some differences. Proline had much lower RF values, this may be due to the testing procedure used. DMI fungicides should be applied a mancozeb or copper mixing partner. Copper inhibits spore germination. A PCR test has been developed to detect DMI resistance, this test may be validated for use in 2020.

4. The presence of isolates with the G143A mutation that results in resistance to Headline continues to be prevalent and widespread, as in 2017 and 2018. These findings preclude the effective use of Headline for CLS management in 2018. Headline is not recommended for Cls management but can be used for frost protection.

5. We recommend continuing disease control recommendations currently in place including fungicide rotation, using high label rate of fungicides, mixtures with mancozeb or copper, scouting at end of the season to decide the necessity of a late application, using fungicide resistance maps for fungicide selection, using a resistant variety, spray intervals of 14 days, and applying fungicides to insure maximum coverage. Improvements in fungicide coverage using proper spray nozzles and spray parameters such as timing, rate, interval and coverage should be implemented.

We urge the use of varieties with better Cls resistance, and these may be available in 2020.

Based on our lab observations, we recommend better cultural practices such as earlier fungicide application and destruction of initial inoculum at field edges to provide better disease control that will help with fungicide resistance management in Cls sugarbeet system.

Figure 1. Incidence and severity of tin resistance in *C. beticola* isolates collected from sugarbeet fields in ND and MN from 2003 to 2019

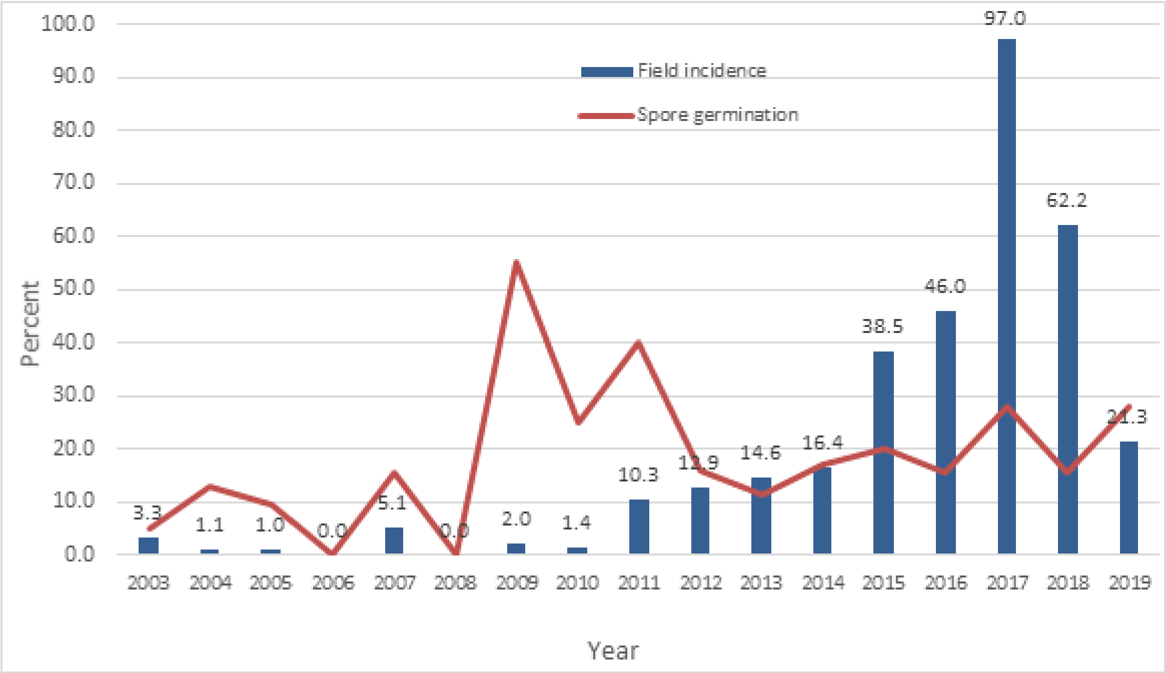


Figure 2. Incidence of fields with *C. beticola* isolates resistant to tin collected in ND and MN from 2015 to 2019 by factory dist

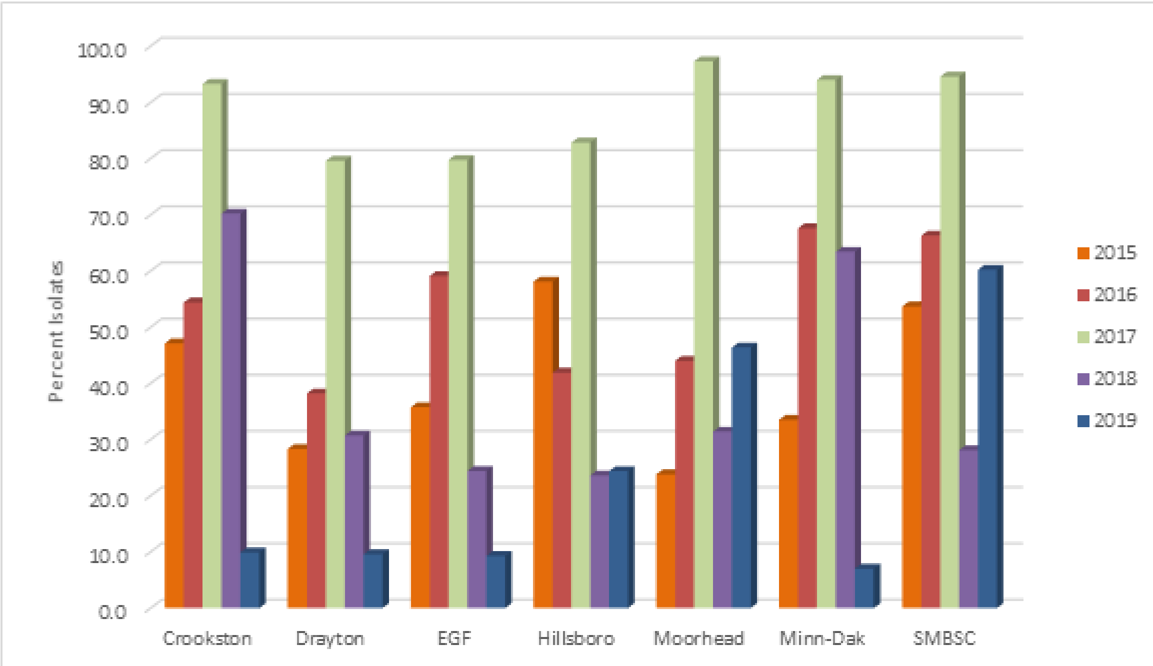


Figure 3**.** Percent of *Cercospora beticola* field isolates collected in ND and MN from 1999 to 2018 with growth on medium amended with Topsin at 5 µg/ml (* Data from 2018 and 2019 based on PCR testing for the E198A mutation)

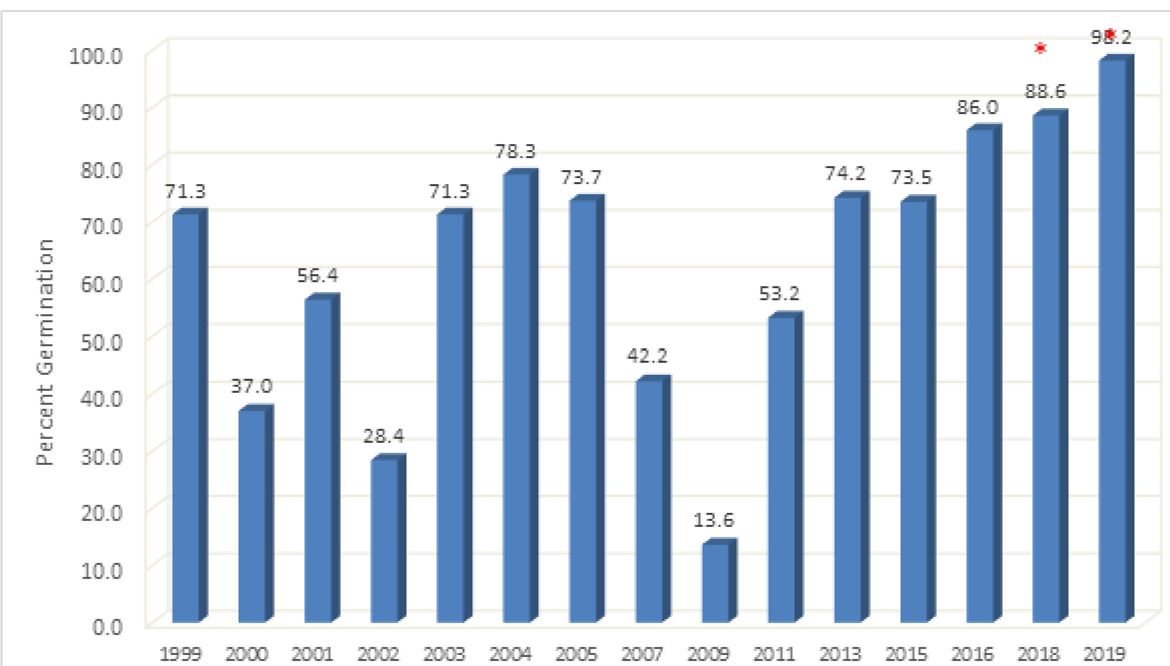


Figure 4. Resistance Factor of C. beticola isolates collected in ND and MN from 2017 to 2019 to Eminent, Inspire Proline and Provysol

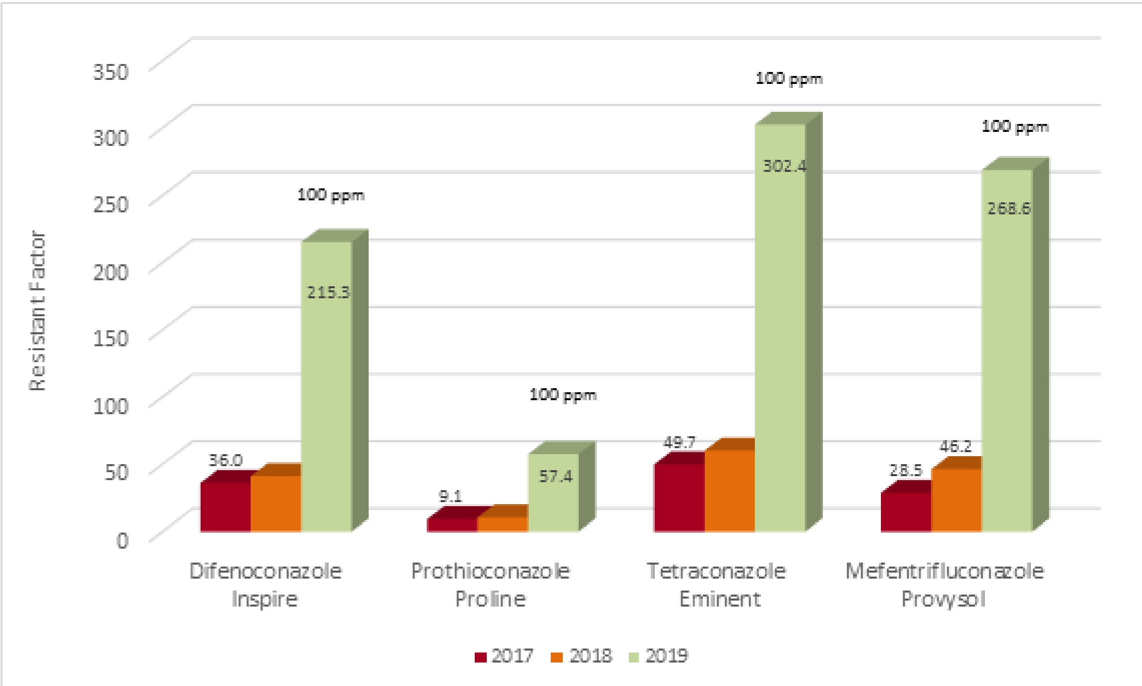


Figure 5. Distributin of sensitivity to Eminent, Inspire, Proline and Provysol of *C. beticola* isolates collected in 2019 as expressed by RF values

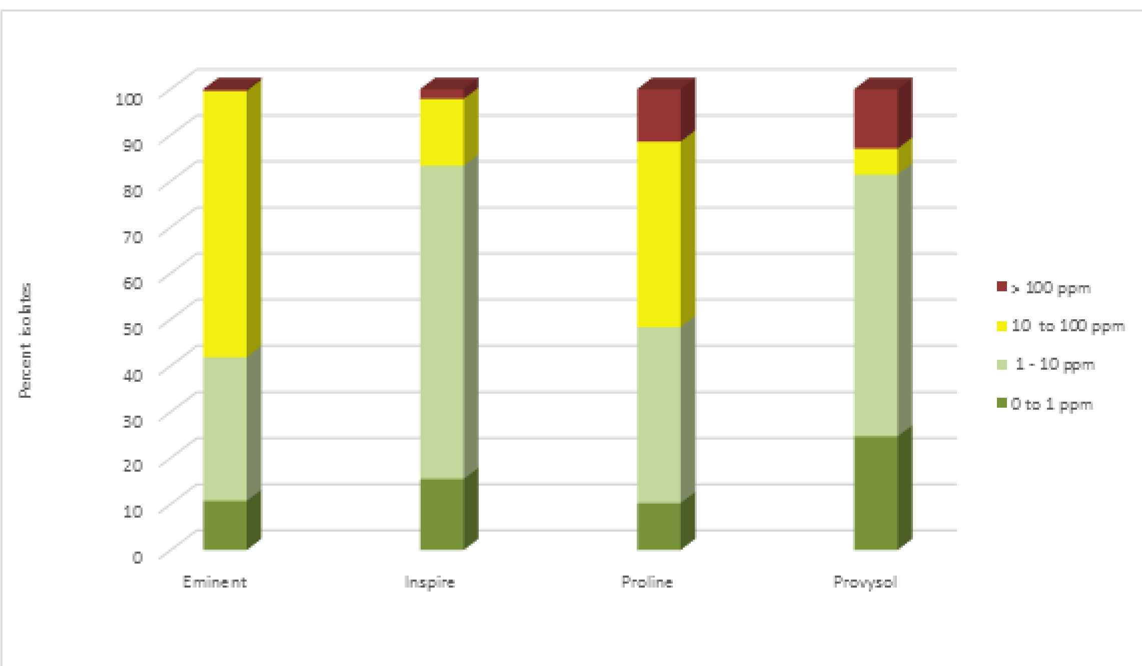


Figure 6. Sensitivity of *C. beticola* isolates collected in 2019 to Eminent, Inspire, Proline* and Provysol by factory district as expressed by RF values

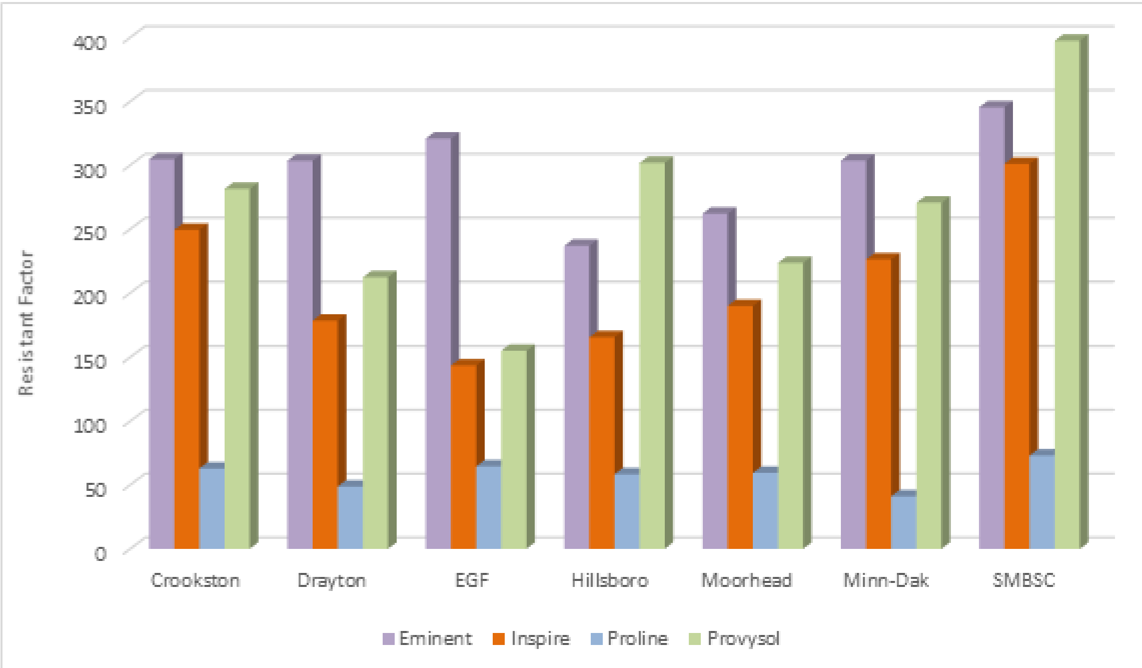
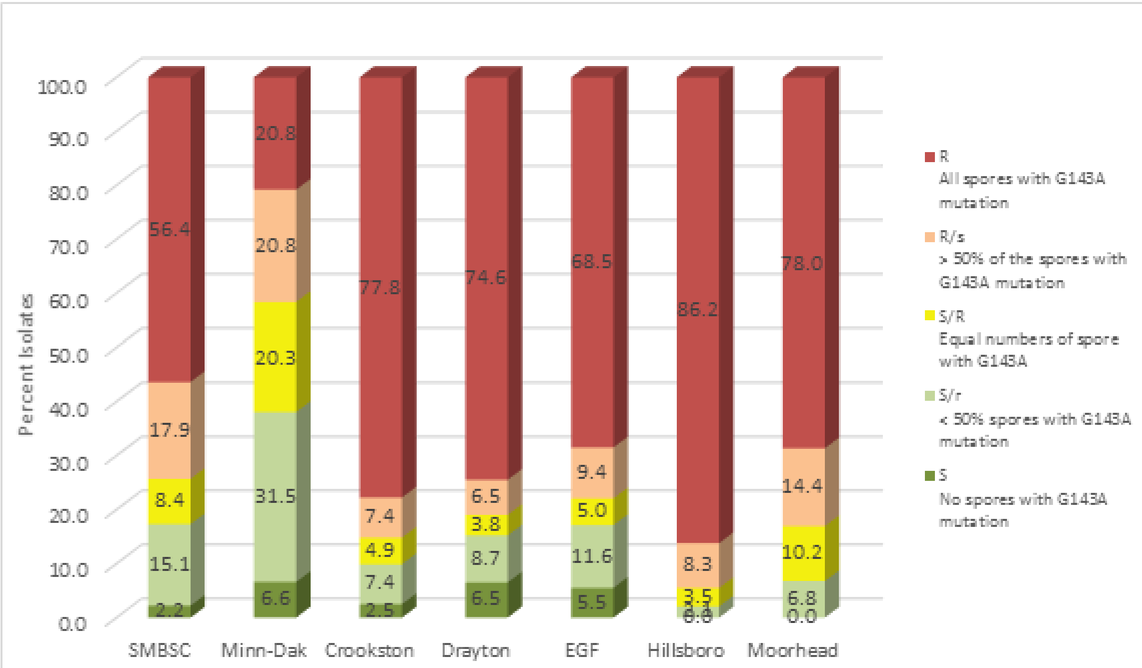


Figure 7. Sensitivity of *C. beticola* isolates collected in ND and MN to Headline from 2012 to 2019 as expressed by the percentage of spores with G143A mutation

Figure 8. Sensitivity of *C. beticola* isolates collected in ND and MN in 2018 to Headline by factory district as measured by the percentage of spores with G143A mutation



Detection of QoI fungicide resistant *Cercospora beticola* airborne inoculum using quantitative PCR

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Cercospora leaf spot (CLS) caused by the fungus *Cercospora beticola* Sacc. is a devastating foliar disease of sugar beet (*Beta vulgaris* L.) worldwide. Under favorable conditions CLS could result in losses up to 40% or greater, and 30% losses in recoverable sucrose due to CLS are common under moderated disease conditions (Khan et al., 2001). This disease is considered the most important constraint for sugar beet production in North Dakota and Minnesota, and warrants multiple fungicide applications per growing season. Despite multiple fungicide applications, unsatisfactory control of the disease has been noticed in some production areas. Development of fungicide resistance in pathogen populations is considered the reason for this. Thus, monitoring of the pathogen population for prevalence of fungicide resistance is essential for effective management of the disease using fungicides.

Spore traps coupled with DNA amplification methods have been used successfully to monitor (detect and quantify pathogen spores) several airborne pathogens including *Peronospora effuse* (Klosterman et al., 2014), *Leptosphaeria maculans* (Calderon et al., 2002) *, L. biglobosa, Pyrenopezzia brassicae* (Calderon et al., 2002), *Botrytis squamosa* (Carisse et al., 2009), *Erysiphe necator* (Falacy et al., 2007), *Sclerotinia sclerotiorum* (Rogers et al., 2009), and *Fusarium circinatum* (Schweigkofler et al., 2004). Previous research has showed that *C. beticola* conidia can be collected in sugarbeet fields using spore traps (Khan et al. 2009). Molecular assays to detect and quantify QoI resistance (G143A) in *C. beticola* are available (Bolton et al. 2013).

The objective of this research was to assess the possibility of using qPCR methods to monitor QoI-resistant *C. beticola* in airborne inoculum trapped using spore samplers placed in sugarbeet fields so that the best time to apply appropriate fungicides could be recommended for growers.

MATERIALS AND METHODS

In 2016, preliminary studies were conducted in Foxhome, MN and Hickson, ND using Burkard volumetric spore samplers to study the feasibility of extracting DNA from trapped spores on adhesive coated tapes and its usability for subsequent molecular detection assays. In 2017, experiments were conducted in Foxhome, MN using two types of spore samplers (Burkard's volumetric and cyclone sampler) to compare for their ease of DNA extraction from trapped spores and sensitivity of detection of *C. beticola* airborne inoculum.

DNA extraction and quantitative real-time PCR assays

In 2016, pieces of tapes representing each day (≈ 48 mm) were cut into 4-6 equal sized smaller sections, and DNA from the airborne inocula trapped on the tapes were extracted following the method described in Rogers et al. 2009 or using Qiagen DNeasy plant mini kit with some modifications. In 2017, tapes were processed similar to the previous year, except that the tapes representing each day were cut into two halves; one portion was used for microscopic observation and the other half was used for DNA extraction. DNA from both the tapes and micro-centrifuge tubes were extracted using the Qiagen kit. Real time PCR assay to detect G143A mutation was conducted as described in Bolton et al. 2013.

RESULTS AND DISCUSSION

In 2016, results showed that DNA can be successfully isolated from the trapped spores on adhesive tapes, following either of the two extraction methods. Further, qPCR assays have successfully detected the presence the *C. beticola* QoI sensitive and resistant isolates in both Foxhome, MN (Table 1) and Hickson, ND (data not presented).

Table 1. Detection of *C. beticola* QoI fungicide resistance mutations using a qPCR assay from spores trapped on adhesive tapes collected from Foxhome, MN.

Tape	Sensitive Isolates	Resistant isolates
1	Y	Y
2	N	Y
3	N	Y
4	N	Y

In 2017, microscopic observations showed that the daily number of *C. beticola* conidia trapped on tapes varied during the sampling period (Fig. 1).

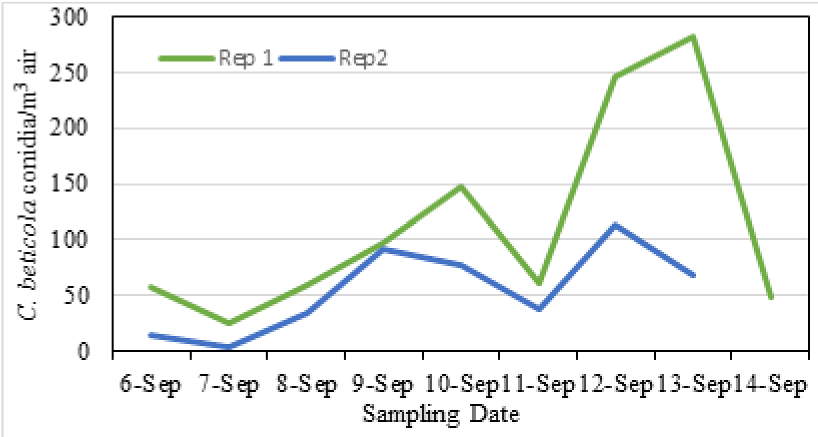

Figure 1. Daily number of *C. beticola* conidia collected with volumetric spore sampler in 2017 season at Foxhome, MN.

Similar to 2016, DNA was successfully isolated from *C. beticola* spores trapped either on tapes or micro-centrifuge tubes. Compared to tapes, DNA extraction from the tubes was found to be easy and efficient. Proportion of QoI resistant *C. beticola* spores varied within the sampling dates (Fig. 2). The qPCR data showed consistency between the volumetric sampler and cyclonic samplers in detection of QoI resistant *C. beticola.*

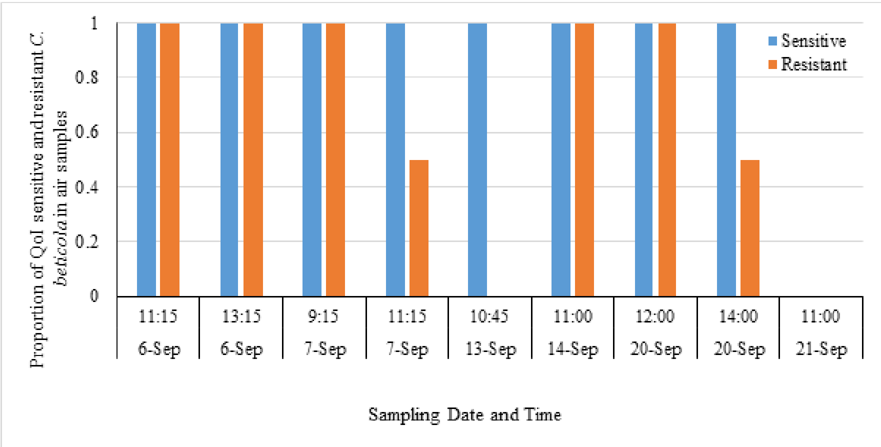

Figure 2. Proportion of QoI sensitive and resistant *C. beticola* in air samples collected using cyclonic sampler. Proportions are calculated as the ratio between the number of replications with positive detections to total number of replications at each time point.

Results from this study suggest that by using cyclonic samplers and qPCR assays, *C. beticola* can be monitored for QoI resistance in real time. Further, molecular detection assays can be extended for other fungicide classes as they become available.

References

Bolton, M. D., Rivera-Varas, V., and Secor, G.2013. Identification of the G143A mutation associated with QoI resistance in *Cercospora beticola* field isolates from Michigan, United States. Pest Manag. Sci. 69:35-39

Calderon, C., Ward, E., Freeman, J., Foster, S. J., and McCartney, H. A. 2002 Detection of airborne inoculum of *Leptosphaeria maculans* and *Pyrenopeziza brassicae* in oilseed rape crops by polymerase chain reaction (PCR) assays. Plant Pathol. 51:303-310.

Carisse, O., Tremblay, D. M., L´evesque, C. A., Gindro, K., Ward, P., and Houde, A. 2009. Development of a TaqMan real-time PCR assay for quantification of airborne conidia of *Botrytis squamosa* and management of Botrytis leaf blight of onion. Phytopathology 99: 1273–1280.

Falacy, J. S., Grove, G. G., Mahaffee, W. F., Galloway, H., Glawe, D. A., Larsen, R. C., and Vandermark, G. J. 2007. Detection of *Erysiphe necator* in air samples using the polymerase chain reaction and species-specific primers. Phytopathology 97:1290-1297.

Khan J, Qi A, Khan MFR. 2009. Fluctuations in number of *Cercospora beticola* conidia in relationship to environment and disease severity in sugar beet. Phytopathology. 99:796–801.

Khan, M., Smith, L., Bredehoeft, M., and Roehl, S. 2001. Cercospora leaf spot control in eastern North Dakota and Minnesota in 2000. Sugarbeet Research and Extension reports:32: 303-310.

Klosterman, S. J., Anchieta, A., McRoberts, N., Koike, S. T., Subbarao, K. V., Voglmayr, H., Choi, Y., Thines, M., and Martin, F. 2014. Coupling Spore Traps and Quantitative PCR Assays for Detection of the Downy Mildew Pathogens of Spinach (*Peronospora effusa*) and Beet (*P. schachtii*). 104:1349-1359.

Rogers, S. L., Atkins, S. D., and West, J. S. 2009. Detection and quantification of airborne inoculum of *Sclerotinia sclerotiorum* using quantitative PCR. Plant Pathol. 58: 324-331.

Rupel, E. G., and Scott, P. R. 1974. Strains of *Cercospora* resistant to benomyl in the U.S.A. Plant Dis. Rep. 58:434-436.

Schweigkofler, W., O'Donnell, K., and Garbelotto, M. 2004. Detection and quantification of airborne conidia of *Fusarium circinatum*, the causal agent of pine pitch canker, from two California sites by using a real-time PCR approach combined with a simple spore trapping method. Appl. Environ. Microbiol. 70:3512-3520. 29.

PRELIMINARY REPORT ON THE EFFECT OF ADJUVANTS WITH FUNGICIDES FOR CONTROLLING CERCOSPORA LEAF SPOT

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most economically damaging foliar disease of sugarbeet in Minnesota and North Dakota. The disease reduces root yield and sucrose concentration and increases impurity concentrations resulting in reduced extractable sucrose and higher processing losses (Smith and Ruppel, 1973; Khan and Smith, 2005). Roots of diseased plants do not store well in storage piles that are processed in a 7 to 9 month period in North Dakota and Minnesota (Smith and Ruppel, 1973). Cercospora leaf spot is managed by integrating the use of tolerant varieties, reducing inoculum by crop rotation and tillage, and fungicide applications (Khan et al; 2007). It is difficult to combine high levels of Cercospora leaf spot resistance with high recoverable sucrose in sugarbeet (Smith and Campbell, 1996). Consequently, commercial varieties generally have only moderate levels of resistance and require fungicide applications to obtain acceptable levels of protection against Cercospora leaf spot (Miller et al., 1994) under moderate and high disease severity. Fungicides are typically applied during a period when there may be regular rainfall. Growers will like to know if adjuvants will help to improve the efficacy of fungicides for controlling CLS.

The objective of this trial was to determine if adjuvants added to fungicides improved control of Cercospora leaf spot.

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2019. The experimental design was a randomized complete block with four replicates. Field plots comprised of six 30-feet long rows spaced 22 inches apart. Plots were planted on 14 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), Kabina, Metlock Rizolex and Nipsit Suite. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5 %v/v; Interlock @ 4 fl oz per acre) on 10 June and (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5% v/v; Interlock @ 4 fl oz per acre) 27 June as well as hand weeding throughout the summer. Quadris (14.3 fl oz per acre) was applied on 5 June and 19 June to control *Rhizoctonia solani*. Plots were inoculated on 12 July with *C. beticola* inoculum.

Fungicide spray treatments were applied with a CO_2 pressurized 4-nozzle boom sprayer with 11002 TT TwinJet nozzles calibrated to deliver 17 gpa of solution at 60 p.s.i pressure to the middle four rows of plots. Fungicide treatments were initiated on 23 July. Treatments included four fungicide applications on 23 July (application A), 6 August (application B), 19 August (application C) and 30 August (application D). Treatments were applied at rates indicated in Table 1.

Cercospora leaf spot severity was rated on the leaf spot assessment scale of 1 to 10 (Jones and Windels, 1991). A rating of 1 indicated the presence of 1- 5 spots/leaf or 0.1% disease severity and a rating of 10 indicated 50% or higher disease severity. Cercospora leaf spot severity was assessed five times during the season. The rating performed on 13 September is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 24 September. The middle two rows of each plot were harvested and weighed for root yield. Twelve to 15 representative roots from each plot, not including roots on the ends of the plot, were analyzed for quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager, version 2019.4 software package (Gylling Data Management Inc., Brookings, South Dakota). The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant.

RESULTS AND DISCUSSIONS

Later than normal planting and unfavorable growing conditions resulted in slow plant growth and row closure in mid-July. Likewise, development of *C. beticola* was very slow after inoculation with first observed symptoms about 10 days later. On 20 August, CLS rating for the non-treated check was 5.8, still below the CLS rating (6.0) at which economic losses typically occur. Warmer conditions in late-August and early September resulted in more favorable conditions for rapid disease development as indicated by a CLS rating of 9.0 and 10.0 for the non-treated check on September 3 and 13, respectively.

All the fungicide treatments provided significantly better disease control than the non-treated check (Table 1). Most of the fungicide treatments resulted in significantly higher tonnage, sucrose concentration and recoverable sucrose than the non-treated check. The results suggest that the use of Transfix with Penncozeb and Badge SC may adversely impact tonnage, sucrose concentration and recoverable sucrose. Preference and Complex adjuvants did not have an adverse effect on any of the parameters evaluated. Badge SC mixed with Complex resulted in better disease control and significantly higher recoverable sucrose compared to the use of Badge SC alone. The addition of adjuvants to mixtures of fungicides in a rotation program did not significantly impact disease control nor yield (tonnage and recoverable sucrose).

Table 1. Effect of fungicides and adjuvants on Cercospora leaf spot control and sugarbeet yield and quality at Foxhome, MN in 2019.

Treatment and rate/A and timing	CLS Rating	Root yield	Sucrose concentration	Recoverable sucrose	
	0-10	Ton/Acre	%	Lb/Ton	Lb/Acre
Penncozeb 2 lb (ABCD)	5.3	28.98	14.11	254	7,366
Badge SC 2 pt (ABCD)	6.5	25.25	14.51	263	6,657
Inspire XT 7 fl oz (ABCD)	5.5	28.03	14.23	258	7,241
Super Tin 8 fl oz + Badge SC 2 pt (A) Mankocide 4.3 lb (B) Super Tin 8 fl oz + Manzate Max 1.6 qt (C) Mankocide 4.3 lb (D)	5.0	29.03	14.75	268	7,774
Penncozeb 2 lb + Preference 2 pt/100 gal (ABCD)	5.8	29.83	14.30	260	7,754
Badge SC 2 pt + Preference 2 pt/100 gal (ABCD)	5.8	27.73	14.33	260	7,187
Inspire XT 7 fl oz + Preference 2 pt/100 gal (ABCD)	5.3	28.25	14.99	272	7,684
Super Tin 8 fl oz + Badge SC 2 pt + Preference 2 pt/100 gal (A) Mankocide 4.3 lb + Preference 2 pt/100 gal (B) Super Tin 8 fl oz + Manzate Max 1.6 qt + Preference 2 pt/100 gal (C) Mankocide 4.3 lb + Preference 2 pt/100 gal (D)	4.8	28.70	14.95	274	7,857
Penncozeb 2 lb + Complex 2 pt/100 gal (ABCD)	5.5	28.98	14.27	258	7,493
Badge SC 2 pt + Complex 2 pt/100 gal (ABCD)	5.8	28.25	14.57	265	7,490
Inspire XT 7 fl oz + Complex 2 pt/100 gal (ABCD)	5.5	29.45	14.61	265	7,796
Super Tin 8 fl oz + Badge SC 2 pt + Complex 2 pt/100 gal (A) Mankocide 4.3 lb + Complex 2 pt/100 gal (B) Super Tin 8 fl oz + Manzate Max 1.6 qt + Complex 2 pt/100 gal (C) Mankocide 4.3 lb + Complex 2 pt/100 gal (D)	4.8	28.28	14.96	273	7,715
Penncozeb 2 lb + Transfix 6 fl oz/100 gal (ABCD)	6.5	27.70	13.91	252	6,983
Badge SC 2 pt + Transfix 6 fl oz /100 gal (ABCD)	5.8	24.13	14.30	259	6,292
Inspire XT 7 fl oz + Transfix 6 fl oz /100 gal (ABCD)	5.0	27.83	15.08	275	7,657
Super Tin 8 fl oz + Badge SC 2 pt + Transfix 6 fl oz /100 gal (A) Mankocide 4.3 lb + Transfix 6 fl oz /100 gal (B) Super Tin 8 fl oz + Manzate Max 1.6 qt + Transfix 6 fl oz /100 gal (C) Mankocide 4.3 lb + Transfix 6 fl oz /100 gal (D)	4.8	27.58	15.12	276	7,606
Untreated Check	10.0	22.75	13.27	240	5,454
LSD (P=0.10)	**0.64**	**2.7**	**0.84**	**16.4**	**829**

References

Jones, R. K.., Windels, C. E. 1991. A management model for Cercospora leaf spot of sugarbeets. Minnesota Extension Service. University of Minnesota. AG-FO-5643-E

Khan, J., del Rio, L.E., Nelson, R., Khan, M.F.R. 2007. Improving the Cercospora leaf spot management model for sugar beet in Minnesota and North Dakota. Plant Dis. 91, 1105-1108.

Khan, M.F.R., Smith, L.J. 2005. Evaluating fungicides for controlling Cercospora leaf spot on sugarbeet. J. Crop Prot. 24, 79-86.

Lamey, H. A., Cattanach, A.W., Bugbee, W.M., Windels, C.E. 1996. Cercospora leaf spot of sugarbeet. North Dakota State Univ. Ext. Circ. PP- 764 Revised, 4 pp.

Miller, S.S., Rekoske, M., Quinn, A., 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infection. J. Sugar Beet Res. 31, 7-12.

Shane, W.W., Teng, P.S., 1992. Impact of Cercospora leaf spot on root weight, sugar yield and purity. Plant Dis. 76, 812-820.

Smith, G.A., Campbell, L.G., 1996. Association between resistance to *Cercospora* and yield in commercial sugarbeet. Plant Breed. 115, 28-32.

Smith, G.A., Ruppel, E.G., 1973. Association of Cercospora leaf spot, gross sugar, percentage sucrose and root weight in sugarbeet. Can. J. Plant Sci. 53, 695-696.

A PRELIMINARY REPORT ON EFFECT OF FUNGICIDES USED AT DIFFERENT WATER VOLUMES IN THE CONTROL OF CERCOSPORA LEAF SPOT

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most economically damaging foliar disease of sugarbeet in Minnesota and North Dakota. The disease reduces root yield and sucrose concentration and increases impurity concentrations resulting in reduced extractable sucrose and higher processing losses (Smith and Ruppel, 1973; Khan and Smith, 2005). Roots of diseased plants do not store well in storage piles that are processed in a 7 to 9 month period in North Dakota and Minnesota (Smith and Ruppel, 1973). Cercospora leaf spot is managed by integrating the use of tolerant varieties, reducing inoculum by crop rotation and tillage, and fungicide applications (Khan et al; 2007). It is difficult to combine high levels of Cercospora leaf spot resistance with high recoverable sucrose in sugarbeet (Smith and Campbell, 1996). Consequently, commercial varieties generally have only moderate levels of resistance and require fungicide applications to obtain acceptable levels of protection against Cercospora leaf spot (Miller et al., 1994) under moderate and high disease severity. Since the advent of glyphosate tolerant sugarbeet, growers typically use low water volume (5 GPA) and effectively controlled weeds. Some growers are using low water volume with fungicides for control of CLS.

The objective of this research was to evaluate the efficacy of fungicides with different water volumes (and different nozzles) for controlling Cercospora leaf spot.

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2019. The experimental design was a randomized complete block with four replicates. Field plots comprised of six 30-feet long rows spaced 22 inches apart. Plots were planted on 14 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), Kabina, Metlock Rizolex and Nipsit Suite. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5 %v/v; Interlock @ 4 fl oz per acre) on 10 June and (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5% v/v; Interlock @ 4 fl oz per acre) 27 June as well as hand weeding throughout the summer. Quadris (14.3 fl oz per acre) was applied on 5 June and 19 June to control *Rhizoctonia solani*. Plots were inoculated on 12 July with *C. beticola* inoculum.

Fungicide spray treatments were applied with a CO_2 pressurized 4-nozzle boom sprayer with 11002 TT TwinJet nozzles, 11002 Turbo Tee Jet nozzles and 8002XR nozzles calibrated to deliver 5, 10, 15, 20 and 25 gpa of solution to the middle four rows of plots. Fungicide treatments were initiated on 23 July. Treatments included four fungicide applications on 23 July, 6 August, 19 August and 30 August. Fungicide treatments were the same over all treatments while the nozzles and gallons per acre changed and are listed in Table 1. The fungicide sequence was Minerva Duo (16 fl oz) followed by Super Tin (8 fl oz) + Topsin (20 fl oz) followed by Proline (5.7 fl oz) + Badge SC (2 pt) + NIS (0.125% v/v) followed by Mankocide (4.3 lb).

Cercospora leaf spot severity was rated on the leaf spot assessment scale of 1 to 10 (Jones and Windels, 1991). A rating of 1 indicated the presence of 1- 5 spots/leaf or 0.1% disease severity and a rating of 10 indicated 50% or higher disease severity. Cercospora leaf spot severity was assessed five times during the season. The rating performed on 13 September is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 25 September. The middle two rows of each plot were harvested and weighed for root yield. Twelve to 15 representative roots from each plot, not including roots on the ends of the plot, were analyzed for quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager, version 2019.4 software package (Gylling Data Management Inc., Brookings, South Dakota). The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant.

RESULTS AND DISCUSSIONS

Later than normal planting and unfavorable growing conditions resulted in slow plant growth and row closure in mid-July. Likewise, development of *C. beticola* was very slow after inoculation with first observed symptoms about 10 days later. On 20 August, CLS rating for the non-treated check was 5.8, still below the CLS rating (6.0) at which economic losses typically occur. Warmer conditions in late-August and September resulted in more favorable conditions for rapid disease development as indicated by a CLS rating of 9.5 for the non-treated check on September 13 (Table 1).

The average disease severity ratings, tonnage, sucrose concentration and recoverable sucrose for the different water volumes (5, 10, 15, 20, 25 gpa) using three different nozzle types are summarized in Table 1. All the fungicide treatments resulted in better disease control, higher tonnage, sucrose concentration and recoverable sucrose compared to the non-treated check. Preliminary data suggest that higher water volumes (10 to 25 gpa) resulted in better disease control and higher recoverable sucrose. Research is ongoing to determine the best combination of water volume, nozzle type, application pressure and droplet size that will provide effective control of CLS and high recoverable sucrose.

Table 1. Effect of Gallons/Acre and Nozzle type on Cercospora leaf spot control and sugarbeet yield and quality at Foxhome, MN in 2019.

Treatment and rate/A	CLS	Root yield	Sucrose concentration	Recoverable sucrose
	1-10	Ton/Acre	%	Lb/Acre
5 GPA; 11002 Turbo Twin Jet & Tee Jet & 8002XR Nozzles	5.9	25.9	14.4	6740
10 GPA; 11002 Turbo Twin Jet & Tee Jet & 8002XR Nozzles	5.1	27.1	14.8	7271
15 GPA; 11002 Turbo Twin Jet & Tee Jet & 8002XR	4.6	28.6	15.1	7827
20 GPA: 11002 Turbo Tee Jet & Tee Jet & 8002XR Nozzles	5.0	28.0	14.7	7484
25 GPA; 11002 Turbo Twin Jet & Tee Jet & 8002XR	4.7	29.1	14.7	7748
Non-treated Check	9.5	22.40	13.33	5,399
LSD (P=0.10)	**0.7**	**2.5**	**0.97**	**874**

References

Jones, R. K.., Windels, C. E.   1991. A management model for Cercospora leaf spot of sugarbeets. Minnesota Extension Service. University of Minnesota. AG-FO-5643-E

Khan, J., del Rio, L.E., Nelson, R., Khan, M.F.R. 2007. Improving the Cercospora leaf spot management model for sugar beet in Minnesota and North Dakota. Plant Dis. 91, 1105-1108.

Khan, M.F.R., Smith, L.J. 2005. Evaluating fungicides for controlling Cercospora leaf spot on sugarbeet. J. Crop Prot. 24, 79-86.

Miller, S.S., Rekoske, M., Quinn, A., 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infection. J. Sugar Beet Res. 31, 7-12.

Smith, G.A., Campbell, L.G., 1996. Association between resistance to *Cercospora* and yield in commercial sugarbeet. Plant Breed. 115, 28-32.

Smith, G.A., Ruppel, E.G., 1973. Association of Cercospora leaf spot, gross sugar, percentage sucrose and root weight in sugarbeet. Can. J. Plant Sci. 53, 695-696.

EFFICACY OF FUNGICIDES FOR CONTROLLING CERCOSPORA LEAF SPOT ON SUGARBEET

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most economically damaging foliar disease of sugarbeet in Minnesota and North Dakota. The disease reduces root yield and sucrose concentration and increases impurity concentrations resulting in reduced extractable sucrose and higher processing losses (Smith and Ruppel, 1973; Khan and Smith, 2005). Roots of diseased plants do not store well in storage piles that are processed in a 7 to 9 month period in North Dakota and Minnesota (Smith and Ruppel, 1973). Cercospora leaf spot is managed by integrating the use of tolerant varieties, reducing inoculum by crop rotation and tillage, and fungicide applications (Khan et al; 2007). It is difficult to combine high levels of Cercospora leaf spot resistance with high recoverable sucrose in sugarbeet (Smith and Campbell, 1996). Consequently, commercial varieties generally have only moderate levels of resistance and require fungicide applications to obtain acceptable levels of protection against Cercospora leaf spot (Miller et al., 1994) under moderate and high disease severity.

The objective of this research was to evaluate the efficacy of fungicides used in rotation to control Cercospora leaf spot on sugarbeet.

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2019. The experimental design was a randomized complete block with four replicates. Field plots comprised of six 30-feet long rows spaced 22 inches apart. Plots were planted on 14 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), Kabina, Metlock Rizolex and Nipsit Suite. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5 %v/v; Interlock @ 4 fl oz per acre) on 10 June and (Roundup Powermax @ 28 fl oz; Outlook @ 6 fl oz; Class Act 2.5% v/v; Interlock @ 4 fl oz per acre) 27 June as well as hand weeding throughout the summer. Quadris (14.3 fl oz per acre) was applied on 5 June and 19 June to control *Rhizoctonia solani*. Plots were inoculated on 12 July with *C. beticola* inoculum.

Fungicide spray treatments were applied with a CO_2 pressurized 4-nozzle boom sprayer with 11002 TT TwinJet nozzles calibrated to deliver 17 gpa of solution at 60 p.s.i pressure to the middle four rows of plots. Most fungicide treatments were initiated on 22 July. Most treatments included four fungicide applications on 22 July, 1 August, 15 August and 29 August. One treatment received applications on a shorter interval and had application dates of 22 July, 31 July, 13 August, 21 August and 29 August. Some treatments also received applications beginning at row closure and were treated on 8 July. Treatments were applied at rates indicated in Table 1.

Cercospora leaf spot severity was rated on the leaf spot assessment scale of 1 to 10 (Jones and Windels, 1991). A rating of 1 indicated the presence of 1- 5 spots/leaf or 0.1% disease severity and a rating of 10 indicated 50% or higher disease severity. Cercospora leaf spot severity was assessed five times during the season. The rating performed on 13 September is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 25 September. The middle two rows of each plot were harvested and weighed for root yield. Twelve to 15 representative roots from each plot, not including roots on the ends of the plot, were analyzed for quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager, version 2019.4 software package (Gylling Data Management Inc., Brookings, South Dakota). The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant.

RESULTS AND DISCUSSIONS

Environmental conditions were not favorable for rapid plant growth resulting in row closure in mid-July. Likewise, development of *C. beticola* was very slow after inoculation with first observed symptoms about 10 days later. On 7 August, CLS rating for the non-treated check was 2.0, still below the CLS rating (6.0) at which economic losses typically occur. Warmer conditions in in mid- to late-August and early September resulted in more favorable conditions for rapid disease development as indicated by a CLS rating of 5.5 and 8.8 for the non-treated check on August 20 and September 3, respectively.

The CLS population, which originated from growers' fields near Foxhome, MN, was resistant to QoI fungicides and had the G143A mutation. The use of fungicide mixtures in a rotation program applied at 14-day intervals and 10 to 12-day intervals effectively controlled CLS. The non-treated check had significantly higher CLS ratings compared to the fungicide treatments (Table 1). The fungicide treatments resulted in significantly higher tonnage, sugar concentration and recoverable sucrose per ton of sugarbeet compared to the non-treated check. The use of fungicide mixtures and timely fungicide applications resulted in effective disease control as measured by the leaf spot ratings through harvest. However, it should be noted that although several treatments had good leaf spot ratings (less than 6), their tonnage and recoverable sucrose were significantly lower than other treatments with similar leaf spot ratings. These differences in yield and recoverable sucrose were probably because plots in some areas were adversely impacted by too much standing water from heavy rainfall in August and September. Treatments where the first fungicide application was made before row closure with subsequent applications at 14-day intervals did not result in any significant improvement in disease control nor recoverable sucrose compared to treatments where the first fungicide application was made at first symptoms and then at 14 day intervals. There were two treatments where no quinone outside inhibitor (QoI) nor demythylation inhibitor (DMI) fungicides were included in the mixtures of the rotation program that resulted in effective control of CLS and high recoverable sucrose. These treatments which comprise mainly of multi-site fungicides may be instrumental in reducing the population of QoI and DMI resistant populations of *C. beticola*.

This research indicated that fungicides should be applied starting promptly at first symptoms of CLS and continued during the season once environmental conditions are favorable for disease development since our fields have a high pathogen population. Each application should comprise of at least two modes of action, and when necessary such as during periods of regular rainfall, spray interval should be reduced from 14 to 12 or 10 days.

General comments for Cercospora leaf spot control in growers' fields in North Dakota and Minnesota where inoculum levels will probably be high in 2020 and CLS tolerant (KWS ratings of 5.2 and less) varieties are grown:

1. The first fungicide application should be made when disease symptoms are first observed (which entails scouting) or soon after row closure especially if the crop was planted early and environmental conditions were favorable for good crop growth. If the first application is late, control will be difficult all season.
2. Since the pathogen population is very high, especially from the central Red River Valley going south, fungicide applications should be made at regular intervals (14 or 10 to 12 during periods with more rainfall).
3. Use mixtures of fungicides that are effective at controlling Cercospora leaf spot in an alternation program.
4. Use the recommended rates of fungicides to control Cercospora leaf spot.
5. During periods of regular rainfall, shorten application interval from 14 days to 12 or 10 days; use aerial applicators during periods when wet field conditions prevent the use of ground rigs.
6. Limit or avoid using fungicides to which the pathogen population has become resistant or less sensitive.
7. Only one application of a benzimidazole fungicide (such as Topsin M 4.5F) in combination with a protectant fungicide (such as Super Tin). The use of multi-site fungicides such as TPTH, Copper, and EBDCs mixed with a QoI or DMI fungicides will increase the effectiveness of the QoIs and DMIs.
8. Avoid using fungicides in an area where laboratory testing shows that the fungus has developed resistance or reduced sensitivity to that particular fungicide or particular mode of action.
9. Use high volumes of water (15 to 20 gpa for ground-rigs and 3 to 5 gpa for aerial application) with fungicides for effective disease control.
10. Based on the 2019 *C. beticola* population and sensitivity testing, CLS spray applications should start at disease onset just after row closure, or when symptoms are first observed in the field, factory district, sentinel plants or in CLS inoculated trials.

The following fungicides in several classes of chemistry are registered for use in sugarbeet:

Strobilurins
- Gem
- (Priaxor)

Sterol Inhibitors
- Eminent/Minerva
- Inspire XT
- Proline
- Revysol
- Enable
- Topguard

Ethylenebisdithiocarbamate (EBDC)
- Penncozeb
- Manzate
- Mancozeb
- Maneb
- (Mankocide)

Benzimidazole
- Topsin

TriphenylTin Hydroxide (TPTH)
- SuperTin
- AgriTin

Copper
- Kocide 2000 and 3000
- Badge SC, Badge X2
- ChampION, Champ DP and WG
- Cuprofix Ultra 40 Disperss
- MasterCop

Products with multiple modes of action include Priaxor, Minerva Duo, Acropolis, Lucento, Mankocide, ProPulse, Delaro, Dexter Max, and Brixen. See publication PP622-20 for more details.

Products within ( ) indicate that they comprise of more than one mode of action.

Table 1. Effect of fungicides on Cercospora leaf spot control and sugarbeet yield and quality at Foxhome, MN in 2019.

Treatment and rate/A	CLS*	Root yield	Sucrose concentration	Recoverable sucrose		Returns**
	1-10	Ton/A	%	lb/Ton	lb/A	$/A
Topsin 20 fl oz + Super Tin 8 fl oz + Manzate Max 1.6 qt/ Inspire XT 7 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt	4.5	29.43	15.84	290	8,534	932
Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Topsin 20 fl oz/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt/ Manzate Max 1.6 qt/ Super Tin 8 fl oz + Priaxor 8 fl oz****	4.3	31.28	15.31	280	8,774	883
Inspire XT 7 fl oz + Super Tin 8 fl oz/ Topsin 20 fl oz + Super Tin 8 fl oz/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt/ Mankocide 4.3 lb	4.3	29.75	15.55	283	8,433	881
Super Tin 8 fl oz + Topsin 20 fl oz/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Priaxor 8 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt	5.0	28.38	15.45	281	8,037	848
Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb	5.0	30.43	15.08	275	8,398	848
Topsin 20 fl oz + Super Tin 8 fl oz/ Minerva Duo 16 fl oz/ Mankocide 4.3 lb/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt	5.5	29.08		280	8,153	837
Super Tin 8 fl oz + Manzate Max 1.6 qt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Mankocide 4.3 lb/	5.0	29.15	15.31	280	8,165	829
Minerva Duo 16 fl oz/ Topsin 20 fl oz + Super Tin 8 fl oz/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt/ Mankocide 4.3 lb	4.8	28.30	15.16	276	7,829	782

Inspire XT 7 fl oz + Topsin 20 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva Duo 16 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt***	4.5	29.60	15.08	274	8,105	782
Super Tin 8 fl oz + Manzate Max 1.6 qt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb	4.8	27.70	15.12	277	7,675	764
Super Tin 8 fl oz + Manzate Max 1.6 qt/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 2 pt/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt	4.3	26.85	15.47	283	7,589	760
Mankocide 4.3 lb/ Badge SC 2 pt + Super Tin 8 fl oz/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Manzate Max 1.6 qt	4.3	29.78	14.74	269	7,996	760
Minerva Duo 16 fl oz + Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt/ Proline 5.7 fl oz + NIS 0.125% + Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt	5.0	29.55	14.90	273	8,083	756
Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Badge SC 2 pt	4.8	29.10	14.54	266	7,795	741
Inspire XT 7 fl oz + Topsin 20 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva Duo 16 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt	5.3	29.35	14.51	264	7,725	731
Mankocide 4.3 lb/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Mankocide 4.3 lb/ Super Tin 8 fl oz + Manzate Max 1.6 qt	5.0	27.00	15.03	275	7,445	724
Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 2.2 lb + Minerva 13 fl oz/ Super Tin 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb + Proline 5.7 fl oz + NIS 0.125%	5.0	28.63	14.64	267	7,661	707
Minerva Duo 16 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Priaxor 8 fl oz + Badge SC 2 pt/ Mankocide 4.3 lb	5.0	27.23	14.85	271	7,400	701
Super Tin 8 fl oz + Mankocide 4.3 lb/ Inspire XT 7 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt****	4.2	27.08	15.05	276	7,472	698
Topsin 20 fl oz + Super Tin 8 fl oz/ Badge SC 2 pt + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% + Badge SC 2 pt	5.0	27.68	14.54	265	7,346	697
Inspire XT 7 fl oz + Topsin 20 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva Duo 16 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% + Manzate Max 1.6 qt****	5.5	27.83	14.68	268	7,475	686
Untreated Check	9.5	23.15	13.51	264	5,687	547
LSD (P=0.05)	**0.7**	**3.0**	**1.1**	**20**	**1023**	**197**

*Cercospora leaf spot measured on 1-10 scale (1 = 1- 5 spots/leaf or 0.1% severity and 10 = 50% severity) on 13 September.

**Returns based on American Crystal payment system and subtracting fungicide costs and application.

***Treatment applied on 10-12 day interval.

******Treatment applications began on 8 July before artificial inoculation**

References

Jones, R. K.., Windels, C. E.   1991. A management model for Cercospora leaf spot of sugarbeets. Minnesota Extension Service. University of Minnesota. AG-FO-5643-E

Khan, J., del Rio, L.E., Nelson, R., Khan, M.F.R. 2007. Improving the Cercospora leaf spot management model for sugar beet in Minnesota and North Dakota. Plant Dis. 91, 1105-1108.

Khan, M.F.R., Smith, L.J. 2005. Evaluating fungicides for controlling Cercospora leaf spot on sugarbeet. J. Crop Prot. 24, 79-86.

Miller, S.S., Rekoske, M., Quinn, A., 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infection. J. Sugar Beet Res. 31, 7-12.

Smith, G.A., Campbell, L.G., 1996. Association between resistance to *Cercospora* and yield in commercial sugarbeet. Plant Breed. 115, 28-32.

Smith, G.A., Ruppel, E.G., 1973. Association of Cercospora leaf spot, gross sugar, percentage sucrose and root weight in sugarbeet. Can. J. Plant Sci. 53, 695-696.

SUGARBEET VARIETIES/QUALITY TESTING

NOTES

RESULTS OF AMERICAN CRYSTAL SUGAR COMPANY'S 2019 CODED OFFICIAL VARIETY TRIALS

William S. Niehaus, Official Trial Manager
Deborah L. Moomjian, Beet Seed Analyst

American Crystal Sugar Company Moorhead, Minnesota

American Crystal Sugar Company's (ACSC) coded Official Variety Trials (OVT) are designed to provide an unbiased evaluation of the genetic potential of sugar beet variety entries under several different environments. The two-year average of these evaluations are then used to establish a list of approved varieties which ensures the use of high quality, productive varieties to maximize returns for growers and the cooperative as a whole.

This report presents data from the 2019 American Crystal OVTs and describes the procedures and cultural practices involved in the trials.

Table	Information in table
1	ACSC approved vareties for 2020
2	Muti-year performance of approved varieties (all locations combined)
3	Performance of ACSC Aphanomyces specialty varieties
4	Performance data of approved conventional varieties (all locations combined)
5	Disease ratings fo ACSC tested varieties (multiple diseases)
6	Root Aphid ratings
7	Official trial sites, cooperators, plant and harvest dates, soil types, and disease notes
8	Seed treatment applied to seed used in the OVTs
9-16	2019 Roundup Ready variety trials and combined trials
17-20	2019 Conventional variety trials and combined trials
21-24	Approval calculations for ACSC market
25	Aphanomyces disease nursery ratings
26	Cercospora disease nursery ratings
27	Rhizoctonia disease nursery ratings
28	Fusarium disease nursery ratings
29	Herbicides and fungicides applied to official trials

Procedures and Cultural Practices

Sugarbeet official variety tests were conducted at the ACSC growing region areas of the Red River Valley by ACSC personnel at the Technical Services Center.

All entries were assigned a code number by KayJay Ag Services. The seed then was sent to ACSC Technical Services Center at Moorhead for official testing.

Thirteen official yield trial sites were planted in the ACSC area with seven harvested. Plant-to-stand trials (4.5 inch spacing) were used to evaluate the commercial, experimental and conventional varieties. Seed companies had the option of treating seed with Tachigaren, insecticide and a Rhizoctonia seed treatment fungicide. The treatments used on the seed planted in the official variety yield trials can be found in table 8.

All seven sites were used for variety approval calculations. One site was abandoned due to erratic emergence (St. Thomas) and two locations were slated to be used for Aphanomyces Specialty (Climax and Perley). However, there was not enough disease pressure to warrant Aphanomyces Specialty evaluation. Rhizoctonia was not prevalent in 2019 compared to 2018 in yield trials. Seed treatments and two applications of Quadris were used to control Rhizoctonia. Based upon susceptible plot observations, root aphids were present in low levels at eleven (11) sites. Preliminary root aphid evaluations are presented in table 6.

2019 harvest conditions were challenging and unprecedented. Soil moisture levels remained above average throughout the months of September, October, and into November, combined with snow and freezing conditions…creating difficult harvest conditions in all five Factory Districts for all involved. Taking the adverse weather conditions into consideration, our OVT Harvest Staff were quite fortunate to have completed harvest at seven (7) OVT locations, those sites included Argyle, Bathgate, Casselton, Kennedy, Climax, Glyndon, Scandia and Grand Forks (Conventional Trial Only). OVT site locations remaining too wet for harvest, and therefore abandoned were Grand Forks, Halstad, Hillsboro, Perley, and Northcote.
Yield trials were planted to stand at 4.5 inches. Plots were planted crosswise (90°) to the cooperators' normal farming operations, where possible. Plot row lengths for all official trials were maintained at 46 feet with about 39 feet harvested. Planting was performed with a 12-row SRES vacuum planter. The GPS controlled planter gave good single seed spacing which facilitated emergence counting. Seed companies had the option of treating seed with Tachigaren, insecticide and a Rhizoctonia seed treatment fungicide. Emergence counts were taken on 24 feet of each plot. Multiple seedlings were counted as a single plant if they emerged less than one inch apart. The stands in all yield trials were refined by removing doubles (multiple seedlings less than 1.5 inch apart) by hand but were not further reduced.
Roundup Powermax with Event and full rates of fungicides were applied using a pickup sprayer driven down the alleys. Hand weeding was used where necessary. The micro rate program was used on conventional trials. All yield trials were treated with Quadris in a band during the 2 leaf (9 oz) and 6-10 leaf stage (14 oz) for Rhizoctonia control. Azteroid was applied at plant at Casselton and Grand Forks. Treatments used for Cercospora control in 2019 included Inspire XT/Penncozeb, Agri Tin/Incognito, Proline/Penncozeb, and Headline/Agri Tin. Ground spraying was conducted by ACSC technical staff.
RR varieties with commercial seed were planted in four-row, six replication trials. The RR experimental entries were planted in smaller two-row, four replication trials. Two applications of Roundup were made in the 4-6 (32 oz) and 8-12 (22oz) leaf stages.
All plot rows were measured for total length after approximately 3.5 feet at each end were removed at the end of August, with skips greater than 60 inches being measured for adjustment purposes. Harvest was performed with one customized six row harvester. All harvested beets of each plot were used for yield determination while one sample (approx. 25 lbs) for sugar and impurity analysis was obtained from each plot. Quality analysis was performed at the ACSC Technical Services quality lab in Moorhead.
Varieties were planted in disease nurseries in North Dakota, Minnesota, and Michigan to evaluate varieties for disease tolerance.
ACSC adjusts the Cercospora, Aphanomyces, Rhizoctonia, and Fusarium nursery data each year to provide a consistent target for variety approval criteria.

Acknowledgements

Thanks to the beet seed companies for their participation in the official variety testing program and to all grower-cooperators, dedicated Technical Services staff involved in the official trial plot care, harvest, and data analysis. Special thanks are extended to Dr. Mohamed Khan for Cercospora nursery infection, Dr. Albert Sims for hosting a Rhizoctonia nursery, Randy Nelson for RRV disease ratings, USDA staff in Michigan for Cercospora and Rhizoctonia nursery ratings. The Betaseed staff for Aphanomyces and Cercospora ratings in the Shakopee area, and Kay Jay Ag Services for sampling and coding all variety entries.

Table 1.
Varieties Meeting ACSC Approval Criteria for the 2020 Sugarbeet Crop ++

Roundup Ready ®	Full Market	Aph Spec	Rhc Spec	High Rzm
BETA8337	Yes	Yes		Hi Rzm
BETA8500	Yes	Yes		Hi Rzm
BETA8524	Yes	Yes		Hi Rzm
BETA8606	Yes			Hi Rzm
BETA8629	Yes	Yes		Hi Rzm
BETA8735	Yes	Yes		Hi Rzm
BETA8749	Yes	Yes	New	Hi Rzm
BETA8767	Yes	New		Hi Rzm
BETA8784	Yes	New		Hi Rzm
BETA8815	New			Hi Rzm
BETA8882	New			Hi Rzm
Crystal 093RR	Yes	Yes		Hi Rzm
Crystal 247RR	Yes			Hi Rzm
Crystal 355RR	Yes		Yes	Hi Rzm
Crystal 572RR	Yes			Hi Rzm
Crystal 574RR	Yes	Yes		Hi Rzm
Crystal 578RR	Yes	Yes		Hi Rzm
Crystal 684RR	Yes	Yes		Hi Rzm
Crystal 793RR	Yes	Yes		Hi Rzm
Crystal 796RR	Yes	Yes		Hi Rzm
Crystal 803RR	New	New		Hi Rzm
Crystal 804RR	New	New		Hi Rzm
Crystal 808RR	New	New		Hi Rzm
Hilleshög HM4302RR	Yes		Yes	Rzm
Hilleshög HM4448RR +	Yes			Rzm
Hilleshög HM9528RR	Yes			Hi Rzm
Hilleshög HIL9708	Yes		New	Hi Rzm
Hilleshög HIL9920	Yes			Hi Rzm
Maribo MA109	Yes		Yes	Hi Rzm
Maribo MA504	Yes			Hi Rzm
Maribo MA717	Yes	New		Hi Rzm
Seedex Bronco RR (1863)	Yes			Hi Rzm
Seedex Canyon RR(844TT)	Yes	Yes		Hi Rzm
Seedex Marathon (856)	Yes			Hi Rzm
Seedex RR1887	New			Hi Rzm
Seedex RR1888	New	New		Hi Rzm
SESVdh RR265	Yes			Hi Rzm
SESVdh RR268	Yes	Yes		Hi Rzm
SESVdh RR333	Yes	Yes		Hi Rzm
SESVdh RR351	Yes			Hi Rzm
SESVdh RR371	Yes			Hi Rzm
SESVdh RR375	Yes			Hi Rzm
SESVdh RR285	New	New		Hi Rzm
SESVdh RR289	New			Hi Rzm

Conventional	Full Market	High Rzm
Crystal R761	Yes	Hi Rzm
Crystal 620	Yes	Hi Rzm
Crystal 840	Yes	Hi Rzm
Crystal 950	New	Hi Rzm
Hilleshög HM3035Rz	Yes	Rzm
Seedex 8869 Cnv	Yes	Hi Rzm
SESVanderhave 48777	Yes	Hi Rzm

Aph Spec = variety meets Aphanomyces specialty requirements
Rhc Spec = variety meets Rhizoctonia specialty requirements
Hi Rzm = may perform better under severe Rzm.
New = newly approved

+ Previously approved varieties not meeting current approval standards. According to Approval Policy, may be sold in 2020 Created 11/25/2019

++Roundup Ready sugarbeets are subject to the ACSC RRSB Bolter Destruction Policy

Table 2. Performance Data of RR Varieties During 2017, 2018, 2019 Growing Seasons (All Locations Combined) +++

	Yrs	Rev/Ton ++			Rev/Acre ++			Rec/Ton		Rec/Acre		Sugar		Yield		Molasses		Emerg		Bolter / Ac		CR +		Aph Root+		Rhizoc.+		Fusarium+		Rzm+
Variety	Com	19	2 Yr	2Y%	19	2 Yr	2Y%	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	
Previous Approved # locations		7	17		7	17		7	17	7	17	7	17	7	17	7	17	7	17	7	17	3	6	1	3	3	6	2	4	
BTS 8337	5	46.23	51.58	104	1442	1531	102	327	342	10204	10207	17.34	18.08	31.3	30.1	1.00	0.99	69	75	0	0	4.40	4.52	3.4	3.6	3.6	3.8	3.6	3.9	HI
BTS 8500	3	41.85	47.52	95	1418	1569	105	311	327	10588	10915	16.64	17.41	34.2	33.7	1.09	1.04	65	77	0	0	4.00	4.20	4.3	4.4	4.3	4.3	2.3	2.4	HI
BTS 8524	3	39.93	45.11	91	1408	1533	102	304	319	10742	10913	16.28	17.00	35.4	34.4	1.08	1.07	70	75	0	0	4.52	4.51	4.5	4.3	4.0	4.1	3.1	3.5	HI
BTS 8606	2	43.24	49.09	99	1404	1544	103	316	333	10275	10543	16.82	17.63	32.6	31.9	1.02	0.99	63	73	0	0	4.69	4.74	5.1	4.8	4.6	4.4	2.7	3.2	HI
BTS 8629	2	41.33	47.19	95	1445	1599	107	309	326	10814	11126	16.52	17.33	35.0	34.3	1.07	1.02	65	69	0	0	4.66	4.59	5.3	4.6	3.9	4.0	3.7	4.1	HI
BTS 8735	1	42.11	49.11	99	1413	1551	103	312	333	10500	10635	16.58	17.61	33.8	32.3	0.99	0.96	63	74	0	0	4.15	4.18	4.5	4.3	4.0	4.0	3.3	3.7	HI
BTS 8749	1	43.77	49.04	98	1393	1495	100	318	333	10122	10206	16.99	17.69	31.9	30.9	1.10	1.06	57	71	3	2	3.95	4.02	3.0	2.9	3.6	3.7	3.0	3.4	HI
BTS 8767	1	43.65	48.57	97	1447	1556	104	317	331	10546	10678	16.90	17.56	33.3	32.5	1.03	1.00	68	78	0	0	4.26	4.29	4.3	4.3	4.1	4.1	2.4	2.9	HI
BTS 8784	1	46.43	51.83	104	1409	1538	103	327	343	9923	10203	17.35	18.09	30.3	29.9	0.98	0.96	54	69	0	0	3.84	3.78	4.4	4.3	4.3	4.4	2.8	3.3	HI
Crystal 093RR	8	45.71	51.22	103	1470	1568	105	325	340	10460	10495	17.26	18.04	32.3	31.0	1.02	1.02	72	79	0	0	5.09	4.98	5.2	4.8	4.1	4.4	3.1	3.7	HI
Crystal 247RR	6	42.12	47.90	96	1330	1500	100	312	329	9838	10332	16.57	17.39	31.5	31.6	0.98	0.97	67	76	0	0	4.50	4.52	4.8	4.9	4.3	4.4	2.5	2.9	HI
Crystal 355RR	4	45.84	50.44	101	1321	1423	95	325	338	9413	9592	17.31	17.94	29.0	28.6	1.05	1.05	72	80	0	0	4.68	4.60	5.0	4.7	3.7	3.7	2.5	3.1	HI
Crystal 572RR	3	47.63	51.97	104	1476	1597	106	332	343	10286	10584	17.55	18.13	31.0	31.0	0.97	0.97	69	76	0	0	4.68	4.56	5.0	4.7	4.1	4.3	2.4	3.0	HI
Crystal 574RR	3	42.50	47.67	96	1436	1585	106	313	328	10623	10977	16.72	17.43	34.0	33.7	1.06	1.04	72	77	0	0	4.28	4.35	4.0	4.2	4.5	4.4	2.0	2.5	HI
Crystal 578RR	2	42.81	48.40	97	1417	1531	102	314	330	10420	10529	16.75	17.53	33.2	32.1	1.03	1.01	72	79	0	0	4.64	4.69	4.9	4.5	4.2	4.3	2.5	2.9	HI
Crystal 684RR	1	41.68	47.25	95	1429	1593	106	310	326	10675	11077	16.58	17.36	34.5	34.2	1.07	1.05	64	76	0	0	4.12	4.27	4.3	4.1	4.0	4.2	2.1	2.5	HI
Crystal 793RR	1	45.92	51.40	103	1555	1680	112	326	341	11046	11209	17.21	17.98	34.0	33.0	0.93	0.92	64	74	0	0	4.04	4.15	3.7	3.5	4.2	4.1	2.7	3.2	HI
Crystal 796RR	NC	42.94	48.32	97	1530	1637	109	315	330	11210	11258	16.77	17.50	35.6	34.3	1.01	0.92	78	83	0	0	4.74	4.74	4.0	3.8	3.9	3.9	2.5	2.9	HI
Hilleshög HM4302RR	6	41.96	47.59	96	1271	1422	95	311	328	9439	9840	16.57	17.36	30.3	30.2	1.00	0.92	56	69	0	0	3.93	4.09	5.2	4.9	4.0	3.8	4.3	4.6	Rzm
Hilleshög HM4448RR	6	43.13	48.60	98	1455	1588	106	316	331	10659	10896	16.75	17.52	33.8	33.1	0.98	0.92	69	77	3	2	5.48	5.37	4.9	4.7	4.0	4.2	4.8	5.0	Rzm
Hilleshög HM9528RR	4	43.73	48.58	97	1455	1544	103	318	331	10587	10595	16.85	17.51	33.4	32.2	0.96	0.92	66	72	0	1	4.93	4.86	4.6	4.4	4.1	4.1	4.2	4.6	HI
Hilleshög HIL9708	2	43.37	48.74	98	1433	1559	104	316	332	10459	10654	16.80	17.55	33.1	32.3	0.98	0.92	72	79	0	0	4.96	4.83	4.6	4.4	3.9	3.8	3.9	4.3	Rzm
Hilleshög HIL9920	1	45.83	51.14	103	1430	1563	104	325	340	10172	10458	17.23	17.96	31.3	30.9	0.97	0.92	70	78	0	0	4.95	4.87	5.1	4.6	4.7	4.7	5.4	5.5	HI
Maribo MA109	4	46.11	51.17	103	1321	1422	95	326	340	9339	9501	17.28	17.98	28.6	28.1	0.97	0.92	52	64	0	0	4.07	4.20	5.3	4.8	3.7	3.7	4.0	4.5	HI
Maribo MA504	3	40.79	46.89	94	1420	1584	106	307	325	10694	11050	16.35	17.25	34.8	34.2	1.00	0.92	69	77	0	0	5.34	5.16	6.2	5.7	4.7	4.5	4.6	4.7	HI
Maribo MA717	1	44.33	50.27	101	1476	1571	105	320	337	10682	10627	16.98	17.83	33.5	31.8	0.99	0.92	70	78	0	0	5.11	4.95	4.4	4.3	4.2	4.2	4.8	4.8	HI
SX Bronco RR	2	44.88	49.79	100	1415	1531	102	322	335	10119	10354	17.11	17.76	31.4	31.0	1.02	0.92	58	68	0	0	4.77	4.71	5.4	4.7	4.7	4.7	5.4	5.5	HI
SX Canyon RR	4	44.10	48.97	98	1434	1554	104	319	333	10396	10614	16.94	17.60	32.7	32.1	0.99	0.92	67	74	0	1	4.58	4.69	5.0	4.7	3.9	4.1	4.7	4.8	HI
SX Marathon RR	3	43.87	49.04	98	1380	1549	103	318	333	10028	10546	16.90	17.60	31.6	31.8	0.99	0.92	55	69	0	0	4.79	5.03	5.1	4.9	4.4	4.3	5.7	5.6	HI
SV RR265	2	44.31	48.76	98	1422	1543	103	320	332	10280	10552	16.94	17.53	32.2	32.0	0.96	0.92	63	73	0	0	4.28	4.38	5.5	4.8	4.3	4.3	5.6	5.5	HI
SV RR268	2	44.33	49.71	100	1408	1544	103	320	335	10166	10467	16.96	17.72	31.9	31.5	0.97	0.92	63	72	0	0	4.82	4.76	5.1	4.6	4.2	4.2	4.9	5.0	HI
SV RR333	4	45.19	50.26	101	1408	1525	102	323	337	10086	10285	17.10	17.80	31.3	30.7	0.96	0.92	70	72	0	0	4.49	4.64	4.7	4.4	4.1	4.2	4.7	4.9	HI
SV RR351	3	44.56	49.40	99	1401	1531	102	321	334	10132	10424	17.02	17.66	31.8	31.4	0.99	0.92	65	72	0	0	4.90	4.76	5.7	5.1	4.1	4.1	5.1	5.2	HI
SV RR371	1	44.55	49.20	99	1377	1500	100	321	333	9920	10214	16.98	17.61	31.0	30.8	0.95	0.92	55	69	0	0	4.34	4.52	5.0	4.8	4.0	4.1	5.2	5.3	HI
Newly Approved																														
BTS 8815	NC	45.96	50.63	102	1458	1564	104	326	338	10338	10510	17.27	17.89	31.8	31.2	0.98	0.97	67	75	0	0	4.61	4.63	5.2	4.6	4.0	4.0	2.7	3.2	HI
BTS 8882	NC	43.24	48.45	97	1445	1577	105	316	331	10550	10823	16.88	17.58	33.3	32.9	1.07	1.04	58	67	0	0	4.18	4.35	5.2	5.1	4.3	4.3	2.9	3.1	HI
Crystal 803RR	NC	47.10	51.34	103	1493	1610	107	329	341	10472	10736	17.45	18.00	31.8	31.6	0.96	0.95	76	83	0	0	3.88	3.95	4.5	4.2	4.5	4.6	2.7	3.4	HI
Crystal 804RR	NC	44.15	48.64	98	1472	1602	107	319	331	10684	10988	16.99	17.59	33.6	33.4	1.03	1.02	62	72	0	0	4.46	4.44	4.3	3.9	3.7	3.9	2.3	2.7	HI
Crystal 808RR	NC	43.05	48.71	98	1456	1614	108	315	332	10711	11059	16.83	17.61	34.1	33.6	1.05	1.03	73	80	0	0	4.78	4.82	3.6	3.6	4.1	4.0	2.4	2.8	HI
SX 1887	NC	46.26	50.42	101	1421	1540	103	327	338	10046	10352	17.31	17.84	30.8	30.8	0.97	0.96	62	70	0	0	4.89	4.89	4.7	4.6	4.2	4.2	4.7	5.0	HI
SX 1888	NC	45.30	50.04	100	1475	1587	106	323	336	10543	10719	17.13	17.77	32.6	32.0	0.96	0.95	61	70	0	0	4.89	4.90	4.6	4.3	4.2	4.4	5.5	5.5	HI
SV 285	NC	45.58	49.76	100	1422	1528	102	324	335	10125	10344	17.19	17.72	31.2	31.0	0.97	0.96	59	71	0	0	4.84	4.68	4.5	4.2	4.4	4.4	4.8	5.1	HI
SV 289	NC	45.57	50.45	101	1376	1533	102	324	338	9838	10313	17.18	17.84	30.5	30.7	0.96	0.95	54	68	0	0	4.59	4.62	5.3	4.9	4.1	4.2	5.8	5.6	HI
SV RR375	NC	45.40	49.79	100	1431	1540	103	324	335	10195	10410	17.13	17.72	31.5	31.1	0.95	0.95	63	74	0	0	4.11	4.54	5.0	4.4	4.0	4.1	5.0	5.2	HI
Benchmark var. mean		45.00	49.83		1394	1500		322	336	10011	10166	17.16	17.81	31.2	30.5	1.05	1.03	65	74											

3 Yr is mean of 3 years data, 3 Y% is 3-Yr mean as % of benchmark varieties. 2 Yr is mean of 2 years data, 2 Y% is 2-Yr mean as % of benchmark varieties. Emergence is % of planted seeds producing a 4 leaf beet. Created 11/25/2019

++2019 Revenue estimate based on a $44.38 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses, 2018 Revenue estimate based on a $46.40 beet payment and 2017 Revenue estimate based on a $48.49 beet payment. Revenue does not consider hauling or prod

+Aph ratings from RRV & Shakopee (res.<4.4, susc>5.0). CR from Randolph MN, Foxhome MN & Michigan (res.<4.4, susc>5.0). Fusarium from RRV (res.<3.0, susc>6.0). Rhizoc. from Mhd, NWROC & Mich (res.<3.8, susc>6). HI may perform better under severe Rzm.

Bolters /Ac are based upon a plant stand of 60,000.

– Indicates data not available.

+++ Sites include Felton, Georgetown, Hillsboro, Climax, Grand Forks, Stephen, Scandia, St. Thomas, Hendrum, Bathgate in 2017.

+++ Sites include Casselton, Bathgate, Scandia, East Grand Forks, St. Thomas, Ada, Glyndon, Hillsboro, Grand Forks, Stephen in 2018

+++ Sites include Casselton, Glyndon, Scandia, Bathgate, Kennedy, Climax, Argyle in 2019

Table 3. Performance Data of RR Aphanomyces Specialty Varieties - Under Aphanomyces Conditions (Relative to Susceptible Checks) approved for 2020 Growing Season +++

	Years	Rev/Ton			Rev/Acre			Rec/Ton		Rec/Acre		Sugar		Yield		CR Rating +		Aph Root +		Fusarium +		Rhizoctonia +	
Description	Comm	2019#	2018	%Sus	2019#	2018	%Sus	2019#	2018	2019#	2018	2019#	2018	2019#	2018	19	2Yr	19	2 Yr	19	2Yr	19	2Yr
# of locations		0	2	2	0	2	2	0	2	0	2	0	2	0	2	3	6	2	3	2	4	3	4
Previously Approved																							
BTS 8337	5	--	44.69	112	--	1240	130	--	314.0	--	8719	--	16.83	--	27.8	4.40	4.52	3.4	3.6	3.6	3.9	3.6	3.8
BTS 8500	3	--	39.44	99	--	1309	137	--	295.7	--	9794	--	15.97	--	33.1	4.00	4.20	4.3	4.4	2.3	2.4	4.3	4.3
BTS 8524	3	--	35.94	90	--	1185	124	--	283.5	--	9388	--	15.40	--	33.2	4.52	4.51	4.5	4.3	3.1	3.5	4.0	4.1
BTS 8629	2	--	38.57	97	--	1286	135	--	292.7	--	9772	--	15.82	--	33.4	4.66	4.59	5.3	4.6	3.7	4.1	3.9	4.0
BTS 8735	1	--	40.15	101	--	1215	127	--	298.2	--	9035	--	16.04	--	30.4	4.15	4.18	4.5	4.3	3.3	3.7	4.0	4.0
BTS 8749	1	--	39.62	100	--	1201	126	--	296.4	--	9005	--	16.02	--	30.5	3.95	4.02	3.0	2.9	3.0	3.4	3.6	3.7
Crystal 093RR	8	--	40.91	103	--	1244	130	--	300.8	--	9138	--	16.27	--	30.3	5.09	4.98	5.2	4.8	3.1	3.7	4.1	4.4
Crystal 574RR	3	--	38.17	96	--	1282	134	--	291.3	--	9778	--	15.75	--	33.6	4.28	4.35	4.0	4.2	2.0	2.5	4.5	4.4
Crystal 578RR	2	--	39.56	99	--	1156	121	--	296.1	--	8661	--	15.96	--	29.3	4.64	4.69	4.9	4.5	2.5	2.9	4.2	4.3
Crystal 684RR	1	--	37.30	94	--	1295	135	--	287.9	--	10015	--	15.60	--	34.9	4.12	4.27	4.3	4.1	2.1	2.5	4.0	4.2
Crystal 793RR	1	--	42.26	106	--	1317	138	--	305.8	--	9553	--	16.37	--	31.3	4.04	4.15	3.7	3.5	2.7	3.2	4.2	4.1
Crystal 796RR	NC	--	38.87	98	--	1288	135	--	293.5	--	9735	--	15.82	--	33.2	4.74	4.74	4.0	3.8	2.5	2.9	3.9	3.9
SX Canyon RR	4	--	40.07	101	--	1199	125	--	297.9	--	8884	--	16.05	--	29.7	4.58	4.69	5.0	4.7	4.7	4.8	3.9	4.1
SV RR268	2	--	41.55	104	--	1236	129	--	303.1	--	9007	--	16.28	--	29.8	4.82	4.76	5.1	4.6	4.9	5.0	4.2	4.2
SV RR333	4	--	41.41	104	--	1172	123	--	302.6	--	8553	--	16.25	--	28.2	4.49	4.64	4.7	4.4	4.7	4.9	4.1	4.2
Newly Approved																							
BTS 8767	1	--	37.52	94	--	1130	118	--	288.7	--	8730	--	--	--	30.4	4.26	4.29	4.3	4.3	2.4	2.9	4.1	4.1
BTS 8784	1	--	42.98	108	--	1253	131	--	308.4	--	9015	--	16.57	--	29.3	3.84	3.78	4.4	4.3	2.8	3.3	4.3	4.4
Crystal 803RR	NC	--	42.04	106	--	1330	139	--	305.0	--	9661	--	16.35	--	31.8	3.88	3.95	4.5	4.2	2.7	3.4	4.5	4.6
Crystal 804RR	NC	--	37.17	93	--	1266	132	--	287.4	--	9823	--	15.60	--	34.3	4.46	4.44	4.3	3.9	2.3	2.7	3.7	3.9
Crystal 808RR	NC	--	40.06	101	--	1301	136	--	297.9	--	9778	--	16.13	--	33.1	4.78	4.82	3.6	3.6	2.4	2.8	4.1	4.0
Maribo MA717	1	--	42.64	107	--	1186	124	--	307.1	--	8578	--	16.43	--	28.1	5.11	4.95	4.4	4.3	4.8	4.8	4.2	4.2
SX 1888	NC	--	41.59	105	--	1254	131	--	303.4	--	9156	--	16.26	--	30.3	4.89	4.90	4.6	4.3	5.5	5.5	4.2	4.4
SV 285	NC	--	40.91	103	--	1217	127	--	300.9	--	8981	--	16.19	--	30.0	4.84	4.68	4.5	4.2	4.8	5.1	4.4	4.4
Aph Susc Checks		--	39.78		--	956		--	296.9	--	7123	--	16.04	--	24.0								
Mean of Aph Specialty Varieties		--	40.32		--	1226		--	298.2	--	9250	--	16.09	--	31.1								

%Susc = % of susceptible varieties.

Created 11/6/2019

+ Aph ratings from Shakopee (res.<4.4, susc>5.0). CR from Randolph MN, Foxhome MN & Michigan (res.<4.4, susc>5.0). Fusarium from RRV (res.<3.0, susc>5.0). Rhizoc. from Mhd, NWROC & Mich (res.<3.8, susc>5).

++ 2019 Revenue estimates based on a $44.38 beet payment at 17.5% sugar and 1.5% loss to molasses. 2018 Revenue estimate based on $46.40 beet payment. Revenue does not consider hauling or production costs.

+++ 2018Data from Climax and Georgetown.

Lack of Aphanomyces pressure at any of the OVT sites prevented collection of Aphanomyces Yield Data for 2019.

Table 4. Performance Data of Conventional Varieties During 2017, 2018, 2019 Growing Seasons (All Locations Combined)

	Yrs	Rev/Ton ++					Rev/Acre ++					Rec/Ton		Rec/Acre		Sugar		Yield		Molasses		Emerg		Bolter / Ac		CR +		Aph Root+		Rhizoc.+		Fusarium+		Rzm+
Variety @	Com	19	2 Yr	2Y%	3Yr#	3Y%	19	2 Yr	2Y%	3Yr#	3Yr%	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	
Previous Approved # locations		3	8		14		3	8		14		3	8	3	8	3	8	3	8	3	8	3	8	3	8	3	6	2	3	3	6	2	4	
Crystal 620	NC	41.74	47.24	97	49.48	99	1394	1631	118	1656	104	311	326	10403	11312	16.59	17.38	33.7	34.9	1.07	1.06	54	67	0	0	3.95	4.13	4.7	4.2	5.1	4.6	2.5	3.0	Hi
Crystal R761	10	38.62	43.53	89	46.06	92	1375	1582	115	1618	101	299	313	10742	11457	16.18	16.86	36.0	36.7	1.21	1.19	61	72	0	0	4.98	4.85	4.4	4.3	4.9	4.6	3.0	3.6	Hi
Crystal 840	NC	39.30	45.48	93	30.32	60	1288	1585	115	NA	--	302	320	9916	11173	16.23	17.10	33.1	35.1	1.15	1.10	52	65	0	0	4.18	4.25	4.0	3.9	4.7	4.4	2.7	3.1	Hi
Hilleshög HM3035Rz	13	43.77	49.17	101	50.89	101	1294	1379	100	1405	88	318	333	9439	9422	16.91	17.65	29.9	28.5	1.02	1.00	72	71	0	0	4.42	4.32	5.1	5.2	4.4	4.2	4.1	4.3	Rzm
Seedex 8869 Cnv	NC	40.88	45.47	93	48.33	96	1374	1617	117	1658	104	307	320	10388	11418	16.40	17.00	33.9	35.8	1.02	1.00	64	74	0	5	4.52	4.59	4.8	4.8	5.1	4.9	3.5	3.7	Hi
SV 48777	NC	45.18	50.25	103	52.63	105	1452	1634	118	1656	104	323	337	10342	10954	17.08	17.78	31.8	32.5	0.94	0.93	63	73	0	0	4.10	4.33	4.9	5.0	5.0	4.7	4.3	4.4	Hi
Newly Approved																																		
Crystal 950	NC	41.21	--	--	--	--	1430	--	--	--	--	309	--	10719	NA	16.49	NA	34.7	--	1.06	--	62	--	0	--	4.72	--	4.8	--	4.8	--	2.9	--	Hi
Benchmark var. mean		44.35	48.87		50.20		1427	1381		1595		320	332	10330	10887	17.07	17.68	32.4	33.0	1.08	1.09	66	75											

Emergence is % of planted seeds producing a 4 leaf beet.

++ 2019 Revenue estimate based on a $44.38beet payment (5-yr ave) at 17.5% sugar and 1.5% loss to molasses.

+ Aph ratings from Shakopee (res<4.4, susc>5.0). CR from Randolph MN, Foxhome MN & Michigan (res<4.5, susc>5.0). Fusarium from RRV (res<3.0, susc>5.0). Rhizoc. from Mhd, NWROC & Mich (res<3.8, susc>5). Hi may perform better under severe Rzm.

Bolters /Ac are based upon a planting base of 60,000 seeds.

+++ Sites include Casselton, Ada, Grand Forks, Scandia, St. Thomas in 2018

+++ Sites include Scandia, Bathgate, Grand Forks in 2019

Table 5. ACSC Official Trial Disease Nurseries 2017 - 2019 (Varieties tested in 2019)

Cercospora, Aphanomyces, Rhizoctonia & Fusarium

		< 4.5 CR > 5.0					< 4.4 Aph > 5.0					< 3.82 Rhizoctonia > 5.0					< 3.0 Fusarium > 5.0					High Rzm
		19	18	17	2 Yr	3 Yr	19	18	17	2 Yr	3 Yr	19	18	17	2 Yr	3 Yr	19	19	17	2 Yr	3 Yr	
Code	Description	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	
	Previously Approved																					
130	BTS 8337	4.40	4.64	4.36	4.52	4.47	3.45	3.74	3.78	3.59	3.65	3.62	4.07	4.30	3.84	3.99	3.57	4.18	3.83	3.87	3.86	Hi Rzm
577	BTS 8500	4.00	4.40	4.29	4.20	4.23	4.30	4.43	4.52	4.37	4.42	4.28	4.36	4.57	4.32	4.40	2.27	2.46	2.14	2.37	2.29	Hi Rzm
503	BTS 8524	4.52	4.50	4.38	4.51	4.47	4.51	4.08	4.49	4.29	4.36	4.00	4.23	4.41	4.12	4.21	3.14	3.93	3.24	3.54	3.44	Hi Rzm
576	BTS 8606	4.69	4.80	4.73	4.74	4.74	5.11	4.43	4.91	4.77	4.81	4.60	4.24	5.00	4.42	4.61	2.68	3.66	2.81	3.17	3.05	Hi Rzm
527	BTS 8629	4.66	4.52	4.29	4.59	4.49	5.32	3.89	4.68	4.61	4.63	3.89	4.02	4.21	3.96	4.04	3.71	4.40	4.20	4.05	4.10	Hi Rzm
521	BTS 8735	4.15	4.21	4.22	4.18	4.19	4.53	4.00	4.74	4.27	4.42	3.95	4.12	4.38	4.04	4.15	3.27	4.04	3.93	3.65	3.75	Hi Rzm
512	BTS 8749	3.95	4.10	4.05	4.02	4.03	2.97	2.79	3.53	2.88	3.10	3.58	3.88	3.95	3.73	3.81	3.04	3.79	3.28	3.41	3.37	Hi Rzm
568	BTS 8767	4.26	4.32	4.16	4.29	4.24	4.32	4.28	4.80	4.30	4.46	4.14	4.10	4.75	4.12	4.33	2.45	3.41	2.71	2.93	2.86	Hi Rzm
572	BTS 8784	3.84	3.73	3.65	3.78	3.74	4.38	4.22	4.59	4.30	4.40	4.29	4.60	4.64	4.44	4.51	2.80	3.76	2.63	3.28	3.07	Hi Rzm
530	Crystal 093RR	5.09	4.88	4.49	4.98	4.82	5.22	4.38	4.43	4.80	4.68	4.14	4.59	4.50	4.37	4.41	3.09	4.28	3.48	3.68	3.61	Hi Rzm
542	Crystal 247RR	4.50	4.54	4.55	4.52	4.53	4.84	5.02	5.35	4.93	5.07	4.32	4.56	4.49	4.44	4.45	2.48	3.34	3.00	2.91	2.94	Hi Rzm
562	Crystal 355RR	4.68	4.52	4.36	4.60	4.52	5.02	4.42	4.84	4.72	4.76	3.67	3.66	4.09	3.66	3.81	2.48	3.73	2.76	3.11	2.99	Hi Rzm
518	Crystal 572RR	4.68	4.45	4.27	4.56	4.47	4.98	4.47	4.69	4.72	4.71	4.14	4.54	4.47	4.34	4.38	2.39	3.70	2.64	3.04	2.91	Hi Rzm
575	Crystal 574RR	4.28	4.42	4.35	4.35	4.35	3.99	4.32	4.72	4.16	4.34	4.45	4.36	4.16	4.41	4.32	2.03	2.87	2.23	2.45	2.38	Hi Rzm
508	Crystal 578RR	4.64	4.74	4.91	4.69	4.76	4.88	4.21	4.56	4.54	4.55	4.21	4.30	4.40	4.25	4.30	2.48	3.36	2.41	2.92	2.75	Hi Rzm
545	Crystal 684RR	4.12	4.41	4.34	4.27	4.29	4.33	3.83	4.31	4.08	4.16	4.01	4.39	4.57	4.20	4.32	2.10	2.96	2.01	2.53	2.36	Hi Rzm
557	Crystal 793RR	4.04	4.26	3.93	4.15	4.08	3.72	3.32	3.02	3.52	3.35	4.18	4.11	4.26	4.15	4.18	2.71	3.59	2.95	3.15	3.09	Hi Rzm
574	Crystal 796RR	4.74	4.74	4.85	4.74	4.78	3.97	3.61	3.11	3.79	3.56	3.85	3.97	4.23	3.91	4.02	2.45	3.36	2.34	2.91	2.72	Hi Rzm
580	Hilleshög HM4302RR	3.93	4.26	3.93	4.09	4.04	5.20	4.65	6.66	4.93	5.50	3.97	3.71	3.60	3.84	3.76	4.25	5.02	5.09	4.64	4.79	Rzm
510	Hilleshög HM4448RR	5.48	5.26	5.28	5.37	5.34	4.86	4.53	6.29	4.70	5.23	4.04	4.38	4.63	4.21	4.35	4.80	5.23	5.35	5.02	5.13	Rzm
543	Hilleshög HM9528RR	4.93	4.79	4.99	4.86	4.90	4.56	4.22	5.63	4.39	4.80	4.10	4.04	4.21	4.07	4.12	4.16	4.95	4.25	4.56	4.45	Hi Rzm
533	Hilleshög HIL9708	4.96	4.71	4.61	4.83	4.76	4.61	4.25	5.94	4.43	4.93	3.87	3.71	4.21	3.79	3.93	3.89	4.61	4.61	4.25	4.37	Hi Rzm
525	Hilleshög HIL9920	4.95	4.79	4.89	4.87	4.88	5.05	4.09	4.94	4.57	4.70	4.68	4.65	4.48	4.67	4.60	5.42	5.51	5.92	5.47	5.62	Hi Rzm
541	Maribo MA109	4.07	4.33	4.14	4.20	4.18	5.28	4.38	5.06	4.83	4.91	3.73	3.69	3.63	3.71	3.69	4.04	4.95	4.23	4.49	4.41	Hi Rzm
504	Maribo MA504	5.34	4.98	5.50	5.16	5.27	6.17	5.30	6.20	5.73	5.89	4.69	4.25	4.37	4.47	4.43	4.61	4.80	4.52	4.70	4.64	Hi Rzm
567	Maribo MA717	5.11	4.78	4.85	4.95	4.91	4.42	4.15	5.31	4.29	4.63	4.15	4.35	4.28	4.25	4.26	4.81	4.86	4.95	4.84	4.88	Hi Rzm
569	SX Bronco RR	4.77	4.65	4.08	4.71	4.50	5.38	4.05	4.88	4.71	4.77	4.71	4.73	4.23	4.72	4.56	5.44	5.52	6.04	5.48	5.67	Hi Rzm
551	SX Canyon RR	4.58	4.79	4.92	4.69	4.76	4.99	4.34	4.33	4.67	4.55	3.89	4.36	4.51	4.12	4.25	4.71	4.93	5.12	4.82	4.92	Hi Rzm
528	SX Marathon RR	4.79	5.27	4.54	5.03	4.87	5.15	4.72	4.52	4.94	4.80	4.36	4.19	4.40	4.28	4.32	5.70	5.51	4.84	5.61	5.35	Hi Rzm
552	SV RR265	4.28	4.48	5.19	4.38	4.65	5.47	4.16	5.35	4.81	4.99	4.25	4.32	4.42	4.29	4.33	5.64	5.44	5.32	5.54	5.47	Hi Rzm
548	SV RR268	4.82	4.70	5.06	4.76	4.86	5.08	4.21	4.71	4.65	4.67	4.21	4.21	4.57	4.21	4.33	4.92	5.12	5.01	5.02	5.02	Hi Rzm
537	SV RR333	4.49	4.78	4.84	4.64	4.70	4.70	4.06	4.99	4.38	4.58	4.08	4.23	4.44	4.16	4.25	4.74	5.14	5.35	4.94	5.08	Hi Rzm
544	SV RR351	4.90	4.61	4.41	4.76	4.64	5.65	4.50	4.18	5.07	4.77	4.09	4.16	4.25	4.12	4.16	5.10	5.30	4.96	5.20	5.12	Hi Rzm
582	SV RR371	4.34	4.71	4.59	4.52	4.55	4.99	4.51	4.55	4.75	4.69	3.97	4.19	4.31	4.08	4.16	5.16	5.36	4.91	5.26	5.14	Hi Rzm
	Newly Approved																					
529	BTS 8815	4.61	4.65	--	4.63	--	5.24	3.97	--	4.60	--	4.03	3.88	--	3.95	--	2.69	3.64	--	3.16	--	Hi Rzm
535	BTS 8882	4.18	4.53	--	4.35	--	5.17	4.98	--	5.07	--	4.27	4.37	--	4.32	--	2.91	3.39	--	3.15	--	Hi Rzm
558	Crystal 803RR	3.88	4.01	--	3.95	--	4.45	3.86	--	4.16	--	4.54	4.67	--	4.60	--	2.70	4.11	--	3.40	--	Hi Rzm
517	Crystal 804RR	4.46	4.42	--	4.44	--	4.30	3.58	--	3.94	--	3.72	4.02	--	3.87	--	2.28	3.05	--	2.66	--	Hi Rzm
547	Crystal 808RR	4.78	4.86	--	4.82	--	3.57	3.60	--	3.58	--	4.09	3.83	--	3.96	--	2.39	3.12	--	2.75	--	Hi Rzm
559	SX 1887	4.89	4.89	--	4.89	--	4.67	4.49	--	4.58	--	4.18	4.16	--	4.17	--	4.68	5.35	--	5.01	--	Hi Rzm
546	SX 1888	4.89	4.92	--	4.90	--	4.65	4.03	--	4.34	--	4.19	4.57	--	4.38	--	5.51	5.47	--	5.49	--	Hi Rzm
561	SV 285	4.84	4.52	--	4.68	--	4.47	3.98	--	4.23	--	4.38	4.35	--	4.37	--	4.76	5.42	--	5.09	--	Hi Rzm
523	SV 289	4.59	4.65	--	4.62	--	5.30	4.42	--	4.86	--	4.06	4.37	--	4.22	--	5.78	5.45	--	5.61	--	Hi Rzm
555	SV RR375	4.11	4.96	5.08	4.54	4.72	5.03	3.83	4.54	4.43	4.47	4.05	4.13	4.25	4.09	4.14	4.97	5.51	5.44	5.24	5.31	Hi Rzm

Created 11/26/2019

Green highlighted ratings indicate specialty or good resistance.
Red highlighted ratings indicate level of concern for some fields.
-- indicates data not available

Table 6

Root Aphid Ratings

Betaseed GH and Hilleshög Field Nursery from 2016 thru 2018 +

	BTS (Infection Severity) (1=Excellent, 5=Poor)			Hilleshög (% Infected) (<10% =Excellent, >20% Poor)			BTS 1-5	Hilleshög % Infect
Variety	2016	2017	2018	2016	2017	2018	Mean	Mean
BETA80RR52	1.6	2.3	1.4	9.7	10.3	12.9	1.8	11.0
BETA8337	1.4	1.2	1.0	9.1	3.8	8.5	1.2	7.1
BETA8500		1.1	1.3		4.1	6.6	1.2	5.4
BETA8524		1.2	1.0		2.0	4.1	1.1	3.1
BETA8606			1.0			1.5	1.0	1.5
BETA8629			1.1			0.6	1.1	0.6
CRYS093RR	1.3	1.0	1.0	22.3	6.4	5.1	1.1	11.3
CRYS247RR	1.1	1.1	1.0	2.8	2.2	10	1.1	5.0
CRYS355RR	2.1	1.4	1.0	4.6	4.9	3.1	1.5	4.2
CRYS467RR		1.9	1.7		10.4	35.5	1.8	23.0
CRYS572RR		1.0	1.0		2.4	2.7	1.0	2.6
CRYS573RR			1.0			6	1.0	6.0
CRYS574RR		1.0	1.0		3.0	8.7	1.0	5.9
CRYS578RR			1.0			9.8	1.0	9.8
HILL4302RR	3.0	2.6	1.6	37.4	22.4	54.2	2.4	38.0
HILL4448RR	2.8	2.9	2.2	70.2	20.3	33.8	2.6	41.4
HILL9528RR	3.2	3.0	3.3	73.2	13.7	83.2	3.2	56.7
HILL9708			1.4			42.2	1.4	42.2
MARI109	2.7	2.5	1.8	43.0	38.3	49.6	2.3	43.6
MARI305RR	2.8	2.8	1.7	72.0	15.1	26.6	2.4	37.9
MARI502		2.9	1.4		17.0	51.2	2.2	34.1
MARI504RR			1.2			62.4	1.2	62.4
SEEDAVALANCHERR		1.8	1.1		8.6	14.8	1.5	11.7
SEEDBRONCORR			1.6			51.9	1.6	51.9
SEEDCANYONRR	2.3	2.3	1.4	41.4	17.8	56.6	2.0	38.6
SEEDCRUZERR	2.2	3.4	1.9	16.4	30.4	52.5	2.5	33.1
SEEDMARATHONRR		2.7	1.4		17.9	37	2.1	27.5
SESRR265			2.5			70.2	2.5	70.2
SESRR266			1.7			46.3	1.7	46.3
SESRR268			1.7			26.2	1.7	26.2
SESRR333	3.2	3.2	1.8	36.3	23.7	20.8	2.7	26.9
SESRR351		3.2	1.7		15.0	43.9	2.5	29.5
ACRARES1 - CRYS246	1.4	1.5	1.7	7.5	7.9	15.1	1.5	10.2
ACRASUSC1 - SES36918	3.1	2.8	1.8	37.8	28.5	57.7	2.6	41.3
ACRASUSC2 - CRYS985	3.0		1.4	69.2		64.9	2.2	67.1
BTS Resistant Check	1.1	1.1	1.0				1.1	--
BTS Susceptible Check	3.5	3.0	2.6				3.0	--
HIL Segregating Check				21.5	10.4	3	--	19.0
HIL Susceptible Check				68.4	24.0	61.7	--	52.3
HIL Tolerant Check				3.8	3.9	9.9	--	3.6
			Legend =	Tolerant	Moderate	Susceptable		

Beta rates plants on severity of infection 1-5 with 1=no aphids, 5=heavy infection.

Hilleshog rates varieties on % infected plants

+ Some varieties in 2019 OVT's were not included inb this evaluation. Refer to approval list for approval status.

Table 7. Planting & Harvest Dates, Previous Crop and Disease Levels for 2019 ACSC Official Trial Sites *

Location	District / Trial Type	Cooperator	Planting Date	Harvest Date	Preceding Crop	Soil Type	Diseases Present @ Aph	Rhc	Rzm	Fus	Maggot	Rt Aphid	Comments
Casselton	Mhd/Hlb	Todd Weber	5/14	9/26	Wheat	Medium/Light	M	L	N	N	N	L	Aph pressure is more on East side.
Glyndon	Mhd/Hlb	Menholt Farms	5/6	9/22	Wheat	Medium/Light	M-V	L-M	N	L	N	N	Aph pressure is moderate to severe.
Perley	Mhd/Hlb	Hoff Farms	6/7	NA+	Corn	Medium	M-V	N	N	N	N	N	Site is very wet
Halstad	Mhd/Hlb	Peter Steen	5/13	NA+	Wheat	Medium	N	N	M	N	N	L	Root Aphid in one corner
Hillsboro	Mhd/Hlb	M&R Steenson Farms	5/21	NA+	Wheat	Medium	N	L	N	N	N	L-M	Root Aphid in all four corners.
Climax	EGF/Crk	Evenson Farms	5/9	10/25	Wheat	Medium/Light	L	L	N	N	N	L	Moderate Aph in NW corner
Grand Forks	EGF/Crk	Drees Farming Association	5/10	9/28	Wheat	Medium/Light	N	L	N	N	L	L	Light Root Maggot on a few beets. RR OVT not harvested
Scandia	EGF/Crk	Dennis Deboer	5/13	9/19	Wheat	Medium	N	L	M	N	N	L	Rzm in three corners. Root aphid in three corners.
Argyle	EGF/Crk	Brent Riopelle	5/4	11/4	Wheat	Medium/Light	N	L	L	N	L	L-M	Rzm in two corners.
Kennedy	Dtn	S & O Beet Farm	5/17	11/3	Wheat	Medium	L-M	N	N	N	N	L-M	Root Aphid in three corners.
St. Thomas	Dtn	Kennelly Farms	5/5	NA+	Wheat	Medium/Light	N	N	N	N	N	L	Harvested proprietary trials only. Poor Stands
Northcote	Dtn	Jesse Strege	5/2	NA +	Wheat	Medium/Heavy	L-M	L-M	N	N	N	L-M	Root Aphid in all four corners. Moderate Aph with some Rhc as secondary infection.
Bathgate	Dtn	Shady Bend Farms	4/25	10/9	Wheat	Medium	N	N	N	N	L	L-M	Moderate Root Aphid in one corner.
Moorhead Fus-N	Fus Nurs	Nelson Farms	5/7	7/2	Soybeans	Medium/Heavy	NA	L	NA	V	NA	NA	
Moorhead Fus-S	Fus Nurs	Oberg Farms	5/15	7/18	Corn	Medium	NA	L	NA	V	NA	NA	
Mhd Rhc-E	Rhc Nurs	Jon Hickel	5/30	8/14	Corn	Heavy	NA	V	NA	L	NA	NA	
Mhd Rhc-W	Rhc Nurs	Jon Hickel	5/12	NA	Corn	Heavy	NA	V	NA	L-M	NA	NA	Excessive rain prevented evaluation.
NWROC Rhc	Rhc Nurs	Albert Sims	5/17	7/26	Soybeans	Medium	NA	M-V	NA	NA	NA	NA	
BSDF Rhc	Rhc Nurs	Mitch McGrath	5/7	8/21	NA	NA	NA	NA	NA	NA	NA	NA	
Shakopee MN	Aphanomyces	Patrick O'Boyle	5/14	8/28	NA	NA	V	NA	NA	NA	NA	NA	
Longmont CO	Root Aphids	Kara Guffey	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Foxhome CR	Cercospora	NDSU/Kevin Etzler	5/14	8/30	Wheat	Medium	NA	NA	NA	NA	NA	NA	
BSDF CR	Cercospora	Mitch McGrath	5/6	8/28	NA	NA	NA	NA	NA	NA	NA	NA	
Randolph MN CR	Cercospora	Patrick O'Boyle	5/4	8/12	NA	NA	NA	NA	NA	NA	NA	NA	

Created 11-25-2019

* Fertilizer applied in accordance to cooperative recommendations.

@ Disease notes for Aph., Rhizoc., Rhizomania, Fusarium, Root Maggot and Root Aphids were based upon visual evaluations (N=none, L=light, M=moderate, V=severe, NA=not observed)

+ Not harvested due to excessive moisture and freezing.

Table 8. Seed Treatments Used on Approved Varieties in Official Variety Trials in 2019

Description	Years in Trial	Years ** Comm.	Fungicide (Rhizoctonia)	Insecticide (Spring Tails & Maggots)	Tachigaren Rate (Aphanomyces)	Priming (Emergence)	Fungicide (Damping Off)
Previous Approved							
BTS 8337	7	5	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8500	5	3	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8524	5	3	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8606	4	2	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8629	4	2	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8735	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8749	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8767	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8784	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
Crystal 093RR	10	8	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 247RR	8	6	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 355RR	7	4	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 572RR	5	3	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 574RR	5	3	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 578RR	5	2	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 684RR	4	1	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 793RR	3	1	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 796RR	3	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Hilleshög HM4302RR	9	6	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HM4448RR	7	6	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HM9528RR	6	4	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL9708	5	2	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL9920	3	1	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA109	6	4	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA504	5	3	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA717	3	1	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
SX Bronco RR	4	2	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX Canyon RR	6	4	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX Marathon RR	5	3	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SV RR265	4	2	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV RR268	4	2	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV RR333	7	4	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV RR351	5	3	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV RR371	3	1	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
Newly Approved							
BTS 8815	2	NC	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8882	2	NC	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
Crystal 803RR	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 804RR	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 808RR	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
SX 1887	2	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1888	2	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SV 285	2	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 289	2	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV RR375	3	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram

NA indicates no treatment applied in this category.

Created 11/25/2019

Table 9. 2019 Performance of Approved RR Varieties - ACSC Official Trials

7 sites

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	326.6	101	10204	102	1.00	46.23	103	1442	103	17.34	31.31	190	1520	306	0	68.8
BTS 8500	122	310.9	96	10588	106	1.09	41.85	93	1418	102	16.64	34.24	216	1629	334	0	65.3
BTS 8524	127	304.0	94	10742	107	1.08	39.93	89	1408	101	16.28	35.40	226	1655	311	0	69.5
BTS 8606	132	315.9	98	10275	103	1.02	43.24	96	1404	101	16.82	32.57	212	1553	303	0	63.4
BTS 8629	115	309.0	96	10814	108	1.07	41.33	92	1445	104	16.52	34.99	234	1461	353	0	65.4
BTS 8735	123	311.8	97	10500	105	0.99	42.11	94	1413	101	16.58	33.81	208	1393	319	0	62.7
BTS 8749	118	317.8	99	10122	101	1.10	43.77	97	1393	100	16.99	31.86	221	1637	338	3	56.7
BTS 8767	129	317.4	99	10546	105	1.03	43.65	97	1447	104	16.90	33.29	206	1560	310	0	68.0
BTS 8784	108	327.3	102	9923	99	0.98	46.43	103	1409	101	17.35	30.33	170	1449	312	0	54.0
Crystal 093RR	110	324.8	101	10460	104	1.02	45.71	102	1470	105	17.26	32.25	170	1551	316	0	71.8
Crystal 247RR	121	311.9	97	9838	98	0.98	42.12	94	1330	95	16.57	31.52	220	1577	261	0	67.1
Crystal 355RR	119	325.2	101	9413	94	1.05	45.84	102	1321	95	17.31	29.04	190	1583	326	0	72.1
Crystal 572RR	124	331.7	103	10286	103	0.97	47.63	106	1476	106	17.55	31.03	164	1446	309	0	69.3
Crystal 574RR	104	313.3	97	10623	106	1.06	42.50	94	1436	103	16.72	34.00	207	1592	320	0	71.5
Crystal 578RR	103	314.3	98	10420	104	1.03	42.81	95	1417	102	16.75	33.18	218	1579	299	0	71.6
Crystal 684RR	133	310.3	96	10675	107	1.07	41.68	93	1429	102	16.58	34.50	227	1620	314	0	64.4
Crystal 793RR	111	325.5	101	11046	110	0.93	45.92	102	1555	112	17.21	34.00	182	1414	282	0	63.8
Crystal 796RR	243	315.0	98	11210	112	1.01	42.94	95	1530	110	16.77	35.56	202	1558	295	0	78.4
Hilleshög HM4302RR	101	311.3	97	9439	94	1.00	41.96	93	1271	91	16.57	30.34	237	1598	265	0	56.0
Hilleshög HM4448RR	109	315.5	98	10659	106	0.98	43.13	96	1455	104	16.75	33.82	190	1464	299	3	69.2
Hilleshög HM9528RR	112	317.7	99	10587	106	0.96	43.73	97	1455	104	16.85	33.38	202	1478	281	0	65.7
Hilleshög HIL9708	105	316.3	98	10459	104	0.98	43.37	96	1433	103	16.80	33.05	221	1466	289	0	71.7
Hilleshög HIL9920	106	325.2	101	10172	102	0.97	45.83	102	1430	103	17.23	31.34	195	1537	276	0	69.6
Maribo MA109	120	326.2	101	9339	93	0.97	46.11	102	1321	95	17.28	28.59	197	1509	279	0	52.0
Maribo MA504	113	307.1	95	10694	107	1.00	40.79	91	1420	102	16.35	34.83	232	1470	296	0	69.1
Maribo MA717	126	319.8	99	10682	107	0.99	44.33	99	1476	106	16.98	33.50	196	1478	301	0	69.5
SX Bronco RR	128	321.8	100	10119	101	1.02	44.88	100	1415	101	17.11	31.40	217	1553	296	0	58.1
SX Canyon RR	102	319.0	99	10396	104	0.99	44.10	98	1434	103	16.94	32.66	181	1491	304	0	67.5
SX Marathon RR	125	318.2	99	10028	100	0.99	43.87	97	1380	99	16.90	31.60	195	1527	291	0	55.3
SV RR265	131	319.7	99	10280	103	0.96	44.31	98	1422	102	16.94	32.21	189	1520	270	0	62.6
SV RR268	116	319.8	99	10166	102	0.97	44.33	99	1408	101	16.96	31.86	185	1515	283	0	63.4
SV RR333	117	322.9	100	10086	101	0.96	45.19	100	1408	101	17.10	31.31	176	1493	280	0	69.7
SV RR351	107	320.6	100	10132	101	0.99	44.56	99	1401	100	17.02	31.76	187	1511	297	0	65.4
SV RR371	114	320.6	100	9920	99	0.95	44.55	99	1377	99	16.98	30.96	181	1518	268	0	55.5
Experimental Trial (Comm status)																	
BTS 8815	202	325.5	101	10338	103	0.98	45.96	102	1458	105	17.27	31.77	196	1604	271	0	66.9
BTS 8882	228	316.0	98	10550	105	1.07	43.24	96	1445	104	16.88	33.33	219	1638	313	0	57.8
Crystal 803RR	227	329.5	102	10472	105	0.96	47.10	105	1493	107	17.45	31.85	172	1454	302	0	76.3
Crystal 804RR	237	319.2	99	10684	107	1.03	44.15	98	1472	106	16.99	33.58	206	1560	311	0	61.7
Crystal 808RR	240	315.4	98	10711	107	1.05	43.05	96	1456	104	16.83	34.07	232	1570	317	0	73.1
SX 1887	238	326.6	101	10046	100	0.97	46.26	103	1421	102	17.31	30.78	180	1520	291	0	61.8
SX 1888	236	323.2	100	10543	105	0.96	45.30	101	1475	106	17.13	32.64	179	1484	291	0	61.1
SV 285	241	324.2	101	10125	101	0.97	45.58	101	1422	102	17.19	31.25	199	1518	282	0	59.1
SV 289	223	324.2	101	9838	98	0.96	45.57	101	1376	99	17.18	30.51	182	1503	282	0	53.6
SV RR375	204	323.6	100	10195	102	0.95	45.40	101	1431	103	17.13	31.50	176	1500	282	0	63.1
Comm Benchmark Mean		322.2		10011		1.05	45.00		1394		17.16	31.15	202	1585	320		64.7
Trial Mean		317.5		10226		1.01	43.70		1404		16.89	32.27	203	1533	301		64.0
Coeff. of Var. (%)		2.9		5.6		9.3	5.8		7.6		2.5	4.8	17.6	4.6	20.1		11.8
Mean LSD (0.05)		5.8		488		0.05	1.61		82		0.27	1.38	25	47	33		4.2
Mean LSD (0.01)		7.6		644		0.07	2.12		108		0.35	1.82	33	62	43		5.5
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from 7 sites — Bolters based upon 60,000 seed per acre. — Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 19ACSExpB

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 10. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Casselton ND

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	294.4	102	10032	101	1.35	37.26	105	1268	103	16.08	34.12	220	1776	496	0	66.4
BTS 8500	122	269.3	93	10518	105	1.44	30.27	85	1181	96	14.91	39.13	253	1971	501	0	62.7
BTS 8524	127	273.0	95	10701	107	1.39	31.29	88	1228	100	15.04	39.21	256	1955	463	0	66.8
BTS 8606	132	284.1	99	10021	100	1.26	34.39	97	1212	99	15.47	35.28	252	1860	391	0	58.9
BTS 8629	115	262.3	91	9729	98	1.50	28.31	80	1047	85	14.61	37.22	296	1812	575	0	65.1
BTS 8735	123	280.4	97	10379	104	1.29	33.36	94	1235	101	15.31	37.02	233	1624	483	0	64.1
BTS 8749	118	283.0	98	10426	105	1.37	34.07	96	1255	102	15.53	36.76	227	1933	467	0	59.4
BTS 8767	129	277.8	96	10443	105	1.34	32.62	92	1224	100	15.23	37.65	266	1845	455	0	67.0
BTS 8784	108	298.0	103	10434	105	1.26	38.26	108	1343	109	16.15	34.94	195	1689	456	0	56.4
Crystal 093RR	110	283.0	98	9579	96	1.42	34.09	96	1157	94	15.57	33.78	216	1878	522	0	67.8
Crystal 247RR	121	271.5	94	9484	95	1.34	30.87	87	1078	88	14.91	34.87	300	1950	407	0	64.1
Crystal 355RR	119	292.2	101	9681	97	1.32	36.64	103	1210	98	15.93	33.28	226	1824	456	0	67.4
Crystal 572RR	124	295.6	102	9975	100	1.31	37.60	106	1268	103	16.09	33.80	191	1759	476	0	66.1
Crystal 574RR	104	273.4	95	10547	106	1.38	31.41	88	1210	98	15.05	38.64	240	1899	474	0	62.8
Crystal 578RR	103	283.6	98	9923	99	1.27	34.25	96	1198	98	15.45	35.01	271	1868	386	0	68.9
Crystal 684RR	133	270.2	94	10704	107	1.43	30.50	86	1214	99	14.94	39.42	272	1928	495	0	58.1
Crystal 793RR	111	294.2	102	11196	112	1.23	37.19	104	1416	115	15.94	38.17	216	1742	414	0	61.1
Crystal 796RR	243	289.0	100	10369	104	1.19	35.77	100	1284	105	15.65	35.85	218	1827	363	0	69.8
Hilleshög HM4302RR	101	272.7	95	8737	88	1.34	31.22	88	1006	82	14.97	31.84	287	1932	415	0	54.7
Hilleshög HM4448RR	109	267.2	93	8878	89	1.36	29.68	83	985	80	14.73	33.27	271	1766	488	0	63.8
Hilleshög HM9528RR	112	279.5	97	9733	98	1.30	33.10	93	1155	94	15.28	34.70	249	1770	446	0	58.8
Hilleshög HIL9708	105	275.1	95	8994	90	1.28	31.88	90	1043	85	15.03	32.52	262	1708	443	0	67.1
Hilleshög HIL9920	106	281.2	97	9383	94	1.29	33.59	94	1119	91	15.35	33.40	255	1837	419	0	62.7
Maribo MA109	120	289.3	100	8807	88	1.32	35.84	101	1092	89	15.79	30.39	257	1820	449	0	45.0
Maribo MA504	113	262.1	91	9177	92	1.34	28.25	79	989	80	14.44	35.00	293	1730	472	0	68.6
Maribo MA717	126	283.9	98	9725	98	1.34	34.33	96	1175	96	15.54	34.28	240	1754	486	0	72.9
SX Bronco RR	128	277.3	96	9044	91	1.40	32.48	91	1059	86	15.26	32.67	298	1909	470	0	47.3
SX Canyon RR	102	275.1	95	9393	94	1.39	31.88	90	1091	89	15.15	34.14	238	1873	494	0	62.7
SX Marathon RR	125	267.5	93	8570	86	1.44	29.77	84	955	78	14.82	31.96	313	1913	498	0	44.5
SV RR265	131	281.0	97	9656	97	1.23	33.53	94	1151	94	15.29	34.51	241	1842	377	0	51.1
SV RR268	116	281.8	98	9589	96	1.31	33.74	95	1150	94	15.41	34.00	225	1890	433	0	53.7
SV RR333	117	286.0	99	9534	96	1.26	34.91	98	1161	95	15.55	33.36	223	1823	407	0	62.1
SV RR351	107	279.4	97	9320	93	1.34	33.07	93	1104	90	15.31	33.34	237	1836	467	0	56.6
SV RR371	114	287.9	100	9181	92	1.27	35.43	100	1128	92	15.67	32.03	218	1811	426	0	44.1
Experimental Trial (Comm status)																	
BTS 8815	202	289.9	101	10015	100	1.30	36.00	101	1245	101	15.79	34.50	262	1882	415	0	57.8
BTS 8882	228	276.3	96	9630	97	1.35	32.26	91	1125	92	15.18	34.84	291	1961	428	0	45.9
Crystal 803RR	227	295.3	102	10923	110	1.15	37.48	105	1388	113	15.91	36.95	200	1674	374	0	66.3
Crystal 804RR	237	270.5	94	10398	104	1.38	30.64	86	1178	96	14.91	38.44	266	1841	483	0	53.0
Crystal 808RR	240	267.3	93	9862	99	1.49	29.78	84	1098	89	14.86	36.89	324	1857	540	0	68.0
SX 1887	238	287.4	100	9227	93	1.32	35.33	99	1134	92	15.69	32.11	232	1830	449	0	52.3
SX 1888	236	289.5	100	9466	95	1.21	35.88	101	1172	95	15.69	32.74	222	1793	389	0	54.2
SV 285	241	282.0	98	9437	95	1.35	33.83	95	1131	92	15.46	33.49	267	1844	462	0	51.0
SV 289	223	279.9	97	9818	98	1.36	33.24	93	1164	95	15.35	35.13	265	1829	474	0	42.5
SV RR375	204	294.0	102	9554	96	1.16	37.12	104	1207	98	15.86	32.46	228	1779	345	0	52.2
Comm Benchmark Mean		288.4		9973		1.34	35.59		1229		15.76	34.63	239	1848	458		60.7
Trial Mean	5001	279.4		9712		1.34	33.08		1150		15.31	34.76	250	1838	456		59.4
Coeff. of Var. (%)	5002	3.7		5.4		7.2	8.7		9.8		3.0	3.5	16.0	4.2	12.3		13.4
Mean LSD (0.05)	5004	12.3		634		0.12	3.44		134		0.54	1.53	49	97	68		9.2
Mean LSD (0.01)	5005	16.3		837		0.16	4.54		177		0.71	2.01	65	128	90		12.2
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Casselton ND   Bolters based upon 60,000 seed per acre.   Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.   Trial # = 198301

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 11. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Glyndon MN

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	314.5	100	8254	102	0.94	42.85	99	1123	101	16.66	26.33	302	1174	302	0	48.2
BTS 8500	122	295.5	94	8263	102	1.07	37.56	87	1047	94	15.85	28.02	358	1317	351	0	47.1
BTS 8524	127	299.5	95	8432	104	0.95	38.67	90	1095	98	15.93	27.92	289	1278	293	0	58.3
BTS 8606	132	300.8	95	8174	101	0.95	39.04	90	1069	96	15.99	26.97	324	1255	284	0	42.7
BTS 8629	115	292.9	93	8689	107	1.07	36.84	85	1104	99	15.72	29.32	381	1262	357	0	48.6
BTS 8735	123	294.9	93	8337	103	1.01	37.41	87	1053	95	15.76	28.45	352	1129	356	0	42.4
BTS 8749	118	304.9	97	7806	96	1.07	40.19	93	1034	93	16.32	25.51	382	1304	344	0	31.6
BTS 8767	129	302.4	96	8181	101	0.89	39.48	91	1074	97	16.00	26.91	291	1264	244	0	51.2
BTS 8784	108	317.8	101	7079	87	1.01	43.76	101	995	89	16.89	21.87	248	1222	364	0	30.1
Crystal 093RR	110	320.5	102	8342	103	0.85	44.53	103	1159	104	16.88	26.00	222	1266	246	0	56.0
Crystal 247RR	121	292.4	93	6865	85	0.92	36.69	85	867	78	15.54	23.33	327	1271	254	0	53.5
Crystal 355RR	119	317.8	101	7911	97	0.92	43.78	101	1096	98	16.81	24.74	257	1221	292	0	50.6
Crystal 572RR	124	322.6	102	8168	101	0.85	45.10	104	1155	104	16.98	25.11	208	1176	270	0	51.1
Crystal 574RR	104	297.3	94	8431	104	0.94	38.07	88	1078	97	15.80	28.33	323	1221	281	0	60.8
Crystal 578RR	103	301.7	96	8232	101	0.96	39.30	91	1078	97	16.04	27.15	317	1281	285	0	58.2
Crystal 684RR	133	291.3	92	8039	99	1.01	36.38	84	1004	90	15.58	27.56	348	1297	313	0	55.6
Crystal 793RR	111	315.0	100	9221	114	0.90	42.98	100	1254	113	16.65	29.41	289	1126	296	0	45.9
Crystal 796RR	243	307.6	97	9343	115	0.90	40.84	95	1236	111	16.24	30.46	243	1234	275	0	58.3
Hilleshög HM4302RR	101	308.6	98	8027	99	0.88	41.22	95	1064	96	16.31	26.20	307	1244	237	0	47.6
Hilleshög HM4448RR	109	312.3	99	9322	115	0.85	42.24	98	1255	113	16.47	30.03	244	1144	266	21	57.2
Hilleshög HM9528RR	112	318.7	101	9951	123	0.82	44.02	102	1374	123	16.76	31.20	269	1096	249	0	55.5
Hilleshög HIL9708	105	303.5	96	9023	111	0.85	39.79	92	1182	106	16.03	29.72	336	1105	245	0	61.4
Hilleshög HIL9920	106	322.8	102	8603	106	0.79	45.18	105	1213	109	16.94	26.53	249	1055	243	0	61.5
Maribo MA109	120	325.5	103	7889	97	0.87	45.91	106	1119	101	17.14	23.95	266	1178	259	0	39.8
Maribo MA504	113	289.4	92	8898	110	0.93	35.87	83	1102	99	15.40	30.75	375	1089	290	0	58.8
Maribo MA717	126	323.0	102	9245	114	0.84	45.23	105	1282	115	17.00	28.87	260	1134	261	0	59.2
SX Bronco RR	128	310.1	98	8108	100	0.90	41.63	96	1101	99	16.41	25.84	314	1092	292	0	46.9
SX Canyon RR	102	325.4	103	9229	114	0.84	45.89	106	1308	118	17.12	28.29	218	1160	265	0	57.6
SX Marathon RR	125	318.1	101	8827	109	0.84	43.85	102	1217	109	16.74	27.70	229	1128	264	0	40.0
SV RR265	131	316.9	100	9012	111	0.82	43.52	101	1240	111	16.66	28.39	242	1157	239	0	53.0
SV RR268	116	313.0	99	8377	103	0.88	42.43	98	1143	103	16.53	26.68	250	1147	280	0	54.1
SV RR333	117	316.9	100	8639	106	0.82	43.53	101	1175	106	16.67	27.46	236	1149	246	0	57.1
SV RR351	107	316.9	100	8991	111	0.90	43.52	101	1231	111	16.75	28.43	241	1188	296	0	55.7
SV RR371	114	319.4	101	8579	106	0.83	44.22	102	1189	107	16.80	26.81	221	1179	247	0	50.8
Experimental Trial (Comm status)																	
BTS 8815	202	323.9	103	8900	110	0.93	45.53	105	1226	110	17.08	27.97	266	1374	258	0	46.0
BTS 8882	228	296.7	94	8347	103	1.03	37.71	87	1047	94	15.85	28.09	300	1396	310	0	49.7
Crystal 803RR	227	318.6	101	8947	110	0.92	44.01	102	1211	109	16.81	28.44	268	1181	296	0	62.8
Crystal 804RR	237	320.7	102	9503	117	0.87	44.61	103	1331	120	16.89	29.32	249	1182	267	0	43.7
Crystal 808RR	240	320.4	101	10150	125	0.85	44.55	103	1416	127	16.86	31.40	250	1173	254	0	62.2
SX 1887	238	317.6	101	7827	96	0.94	43.71	101	1072	96	16.81	24.48	257	1238	299	0	38.9
SX 1888	236	328.2	104	9628	119	0.87	46.78	108	1345	121	17.26	29.67	244	1150	278	0	42.4
SV 285	241	313.6	99	7718	95	0.98	42.57	99	1068	96	16.64	24.32	277	1266	315	0	31.2
SV 289	223	327.5	104	8411	104	0.81	46.58	108	1178	106	17.13	26.16	211	1123	250	0	46.6
SV RR375	204	320.0	101	8546	105	0.81	44.41	103	1187	107	16.79	26.66	216	1086	258	0	42.3
Comm Benchmark Mean		315.7		8116		0.97	43.18		1113		16.75	25.68	293	1237	309		46.1
Trial Mean	5001	309.3		8386		0.92	41.40		1124		16.38	27.07	290	1199	285		50.1
Coeff. of Var. (%)	5002	3.6		6.8		9.8	7.5		9.5		3.1	5.8	19.4	6.1	17.0		13.7
Mean LSD (0.05)	5004	13.8		738		0.11	3.84		139		0.63	2.03	71	88	60		8.4
Mean LSD (0.01)	5005	18.2		974		0.15	5.06		183		0.83	2.68	94	116	79		11.1
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Glyndon MN   Bolters based upon 60,000 seed per acre.   Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.   Trial # = 198302

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 12. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Climax MN

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	323.6	101	11781	103	1.00	45.38	101	1652	104	17.19	36.40	157	1437	337	0	80.7
BTS 8500	122	309.2	96	12999	114	1.07	41.39	92	1738	109	16.53	42.07	158	1495	372	0	82.3
BTS 8524	127	303.7	94	12646	111	1.06	39.84	89	1660	104	16.23	41.62	166	1585	341	0	84.9
BTS 8606	132	312.3	97	12307	108	1.03	42.25	94	1667	105	16.63	39.34	169	1450	346	0	74.7
BTS 8629	115	309.4	96	13284	116	1.04	41.44	92	1778	112	16.51	42.97	188	1333	382	0	83.3
BTS 8735	123	305.7	95	12732	111	0.96	40.39	90	1684	106	16.25	41.61	153	1295	340	0	75.8
BTS 8749	118	322.5	100	12200	107	1.01	45.07	101	1706	107	17.13	37.82	158	1522	325	0	73.4
BTS 8767	129	316.3	98	12488	109	1.04	43.36	97	1714	108	16.86	39.43	151	1388	379	0	82.6
BTS 8784	108	326.5	102	12116	106	0.94	46.20	103	1714	108	17.26	37.11	130	1330	328	0	66.4
Crystal 093RR	110	321.9	100	12668	111	1.04	44.91	100	1767	111	17.14	39.37	136	1468	363	0	86.5
Crystal 247RR	121	314.0	98	11514	101	0.88	42.72	95	1565	98	16.59	36.71	161	1411	246	0	85.2
Crystal 355RR	119	326.8	102	10337	90	1.03	46.29	103	1461	92	17.38	31.66	143	1488	348	0	90.4
Crystal 572RR	124	326.1	101	12118	106	0.93	46.07	103	1711	107	17.23	37.23	144	1289	322	0	86.5
Crystal 574RR	104	312.0	97	12986	114	1.05	42.15	94	1754	110	16.64	41.65	156	1445	370	0	86.5
Crystal 578RR	103	315.3	98	12143	106	1.06	43.07	96	1659	104	16.82	38.48	157	1437	386	0	88.3
Crystal 684RR	133	311.3	97	12641	111	1.00	41.95	94	1703	107	16.56	40.60	158	1482	325	0	85.2
Crystal 793RR	111	328.8	102	13277	116	0.88	46.84	104	1893	119	17.32	40.34	134	1282	294	0	81.8
Crystal 796RR	243	316.4	98	13458	118	0.89	43.34	97	1837	115	16.70	42.88	158	1373	267	0	92.8
Hilleshög HM4302RR	101	319.3	99	11920	104	0.89	44.20	99	1649	104	16.85	37.35	176	1432	245	0	70.3
Hilleshög HM4448RR	109	315.4	98	13002	114	0.98	43.11	96	1777	112	16.75	41.21	139	1348	348	0	82.3
Hilleshög HM9528RR	112	321.0	100	12705	111	0.95	44.67	100	1768	111	17.00	39.59	156	1334	330	0	82.6
Hilleshög HIL9708	105	312.8	97	12554	110	0.93	42.38	95	1699	107	16.57	40.18	178	1335	300	0	83.6
Hilleshög HIL9920	106	329.0	102	12375	108	0.89	46.90	105	1764	111	17.34	37.62	147	1361	274	0	84.1
Maribo MA109	120	331.0	103	12152	106	0.90	47.46	106	1742	109	17.45	36.71	148	1344	284	0	70.3
Maribo MA504	113	307.8	96	12926	113	1.04	40.98	91	1720	108	16.41	42.04	177	1402	370	0	85.2
Maribo MA717	126	311.1	97	12689	111	0.98	41.90	93	1709	107	16.54	40.83	155	1348	349	0	80.7
SX Bronco RR	128	334.3	104	12907	113	0.92	48.37	108	1867	117	17.65	38.62	148	1387	296	0	78.4
SX Canyon RR	102	316.2	98	12844	112	0.97	43.33	97	1760	111	16.79	40.61	153	1364	339	0	84.1
SX Marathon RR	125	318.9	99	12415	109	0.95	44.07	98	1716	108	16.91	38.93	161	1395	307	0	75.0
SV RR265	131	321.8	100	12623	110	0.86	44.89	100	1762	111	16.95	39.22	128	1319	269	0	80.7
SV RR268	116	321.1	100	12172	106	0.91	44.69	100	1694	106	16.98	37.92	137	1341	297	0	82.0
SV RR333	117	320.1	100	11833	103	0.93	44.41	99	1640	103	16.92	37.02	139	1333	315	0	86.7
SV RR351	107	319.9	99	12319	108	0.89	44.36	99	1707	107	16.91	38.50	149	1369	274	0	87.8
SV RR371	114	316.7	98	12384	108	0.92	43.47	97	1700	107	16.76	39.08	156	1390	288	0	69.3
Experimental Trial (Comm status)																	
BTS 8815	202	327.8	102	12032	105	0.97	46.57	104	1722	108	17.34	36.62	163	1467	301	0	76.4
BTS 8882	228	317.4	99	13165	115	1.02	43.64	97	1807	113	16.90	41.65	159	1479	342	0	72.3
Crystal 803RR	227	322.0	100	11167	98	0.97	44.94	100	1538	97	17.07	35.23	138	1311	355	0	92.1
Crystal 804RR	237	314.2	98	12601	110	1.10	42.75	95	1701	107	16.81	40.75	160	1453	413	0	79.9
Crystal 808RR	240	316.0	98	11774	103	1.06	43.24	96	1603	101	16.87	37.42	194	1443	365	0	85.7
SX 1887	238	322.1	100	11769	103	1.00	44.98	100	1643	103	17.11	36.46	143	1347	363	0	73.5
SX 1888	236	323.0	100	12990	114	0.91	45.23	101	1823	115	17.06	40.46	155	1398	280	0	77.2
SV 285	241	316.5	98	11658	102	0.93	43.38	97	1593	100	16.75	37.22	162	1327	308	0	78.5
SV 289	223	324.6	101	12024	105	0.96	45.64	102	1683	106	17.18	37.43	141	1348	332	0	71.0
SV RR375	204	317.0	99	11634	102	0.95	43.54	97	1588	100	16.80	37.20	153	1339	329	0	81.6
Comm Benchmark Mean		321.6		11437		1.03	44.83		1592		17.11	35.61	160	1480	344		79.5
Trial Mean	5001	317.7		12332		0.97	43.73		1696		16.86	38.85	156	1402	326		79.9
Coeff. of Var. (%)	5002	2.5		5.8		8.6	5.1		7.4		2.2	5.3	10.3	4.8	17.1		8.9
Mean LSD (0.05)	5004	9.8		885		0.10	2.74		154		0.45	2.51	20	84	71		8.1
Mean LSD (0.01)	5005	13.0		1168		0.14	3.62		203		0.59	3.31	27	111	93		10.6
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Climax MN — Bolters based upon 60,000 seed per acre. — Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 198306

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 13. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Scandia MN

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	334.0	105	10538	104	1.05	48.29	110	1520	109	17.76	31.49	228	1459	349	0	80.2
BTS 8500	122	310.0	98	11201	111	1.16	41.61	95	1501	108	16.66	36.16	246	1623	376	0	71.5
BTS 8524	127	299.3	94	10453	103	1.28	38.61	88	1346	97	16.27	34.67	361	1630	427	0	76.9
BTS 8606	132	315.3	99	10900	108	1.21	43.07	98	1490	107	16.96	34.63	279	1536	426	0	77.1
BTS 8629	115	307.7	97	11078	109	1.12	40.95	93	1478	106	16.51	35.90	319	1427	374	0	70.7
BTS 8735	123	310.1	98	10826	107	1.13	41.64	95	1452	104	16.63	34.90	273	1357	418	0	72.8
BTS 8749	118	311.1	98	10166	100	1.28	41.89	96	1365	98	16.84	32.62	317	1636	446	0	71.8
BTS 8767	129	317.4	100	11256	111	1.16	43.67	100	1550	111	17.04	35.38	270	1540	395	0	79.3
BTS 8784	108	321.4	101	10159	100	1.11	44.76	102	1414	101	17.17	31.54	214	1459	390	0	63.7
Crystal 093RR	110	324.6	102	10547	104	1.12	45.67	104	1480	106	17.35	32.71	216	1525	387	0	78.7
Crystal 247RR	121	308.6	97	10254	101	1.12	41.22	94	1370	98	16.55	33.28	278	1578	344	0	73.2
Crystal 355RR	119	316.6	100	9649	95	1.20	43.45	99	1324	95	17.03	30.61	260	1557	416	0	84.0
Crystal 572RR	124	334.0	105	10480	103	1.04	48.29	110	1520	109	17.73	31.48	201	1431	353	0	79.9
Crystal 574RR	104	312.8	98	11044	109	1.16	42.38	97	1498	107	16.80	35.43	262	1618	379	0	84.8
Crystal 578RR	103	305.7	96	10601	105	1.26	40.41	92	1404	101	16.55	34.36	303	1565	447	0	81.1
Crystal 684RR	133	304.3	96	11109	110	1.24	40.02	91	1462	105	16.46	36.29	315	1558	428	0	74.8
Crystal 793RR	111	324.0	102	10994	108	1.00	45.49	104	1543	111	17.21	33.95	237	1390	318	0	72.3
Crystal 796RR	243	301.2	95	10651	105	1.32	38.87	89	1380	99	16.43	35.28	289	1619	476	0	91.6
Hilleshög HM4302RR	101	304.0	96	9691	96	1.20	39.92	91	1273	91	16.39	31.91	353	1643	365	0	62.8
Hilleshög HM4448RR	109	314.8	99	10988	108	1.08	42.92	98	1500	108	16.83	34.66	248	1414	373	0	84.9
Hilleshög HM9528RR	112	313.2	99	10570	104	1.11	42.49	97	1432	103	16.77	33.86	278	1504	358	0	73.1
Hilleshög HIL9708	105	315.0	99	10638	105	1.08	43.00	98	1452	104	16.84	33.68	306	1440	346	0	79.5
Hilleshög HIL9920	106	317.1	100	10417	103	1.11	43.59	100	1431	103	16.96	32.95	281	1530	348	0	77.0
Maribo MA109	120	321.5	101	9378	93	1.13	44.80	102	1303	93	17.19	29.34	292	1487	372	0	56.9
Maribo MA504	113	307.9	97	11132	110	1.14	41.00	94	1481	106	16.53	36.26	305	1514	366	0	75.1
Maribo MA717	126	314.2	99	10738	106	1.17	42.76	98	1460	105	16.88	34.38	297	1491	401	0	76.5
SX Bronco RR	128	315.4	99	10369	102	1.07	43.10	98	1416	102	16.84	32.90	271	1532	325	0	65.2
SX Canyon RR	102	314.5	99	10623	105	1.06	42.84	98	1450	104	16.78	33.98	248	1456	344	0	75.2
SX Marathon RR	125	318.7	100	10647	105	1.05	44.01	100	1469	105	16.99	33.37	246	1522	318	0	62.4
SV RR265	131	310.4	98	10026	99	1.15	41.70	95	1347	97	16.67	32.20	274	1552	376	0	63.6
SV RR268	116	318.8	100	10307	102	1.10	44.05	101	1418	102	17.05	32.26	282	1493	352	0	75.1
SV RR333	117	325.1	102	10395	103	1.06	45.80	105	1458	105	17.32	31.99	248	1466	336	0	82.3
SV RR351	107	315.5	99	10737	106	1.08	43.12	98	1469	105	16.86	34.04	258	1499	343	0	73.3
SV RR371	114	320.7	101	10362	102	1.09	44.57	102	1441	103	17.11	32.37	241	1547	349	0	63.0

Table 13 cont

Experimental Trial (Comm status)																	
BTS 8815	202	315.8	99	10176	100	1.15	43.16	99	1388	100	16.96	32.36	272	1660	359	0	84.8
BTS 8882	228	306.3	96	10746	106	1.22	40.39	92	1415	101	16.57	35.23	294	1654	404	0	66.9
Crystal 803RR	227	333.2	105	10916	108	1.02	48.29	110	1579	113	17.64	32.88	193	1438	343	0	82.2
Crystal 804RR	237	325.9	103	11323	112	1.02	46.14	105	1603	115	17.28	34.93	251	1529	306	0	75.2
Crystal 808RR	240	309.5	97	10847	107	1.21	41.30	94	1438	103	16.68	35.44	326	1606	386	0	81.9
SX 1887	238	329.7	104	10668	105	1.04	47.27	108	1527	109	17.50	32.46	221	1509	335	0	77.4
SX 1888	236	321.1	101	10707	106	1.03	44.73	102	1496	107	17.07	33.32	231	1533	324	0	72.5
SV 285	241	316.7	100	9910	98	1.10	43.45	99	1357	97	16.95	31.39	279	1477	362	0	74.3
SV 289	223	311.1	98	9961	98	1.06	41.77	95	1340	96	16.61	31.99	260	1532	324	0	61.6
SV RR375	204	320.1	101	9706	96	1.04	44.44	101	1348	97	17.03	30.41	235	1499	335	0	73.1
Comm Benchmark Mean		317.9		10136		1.19	43.80		1395		17.08	32.03	268	1571	404		76.2
Trial Mean	5001	314		10456		1.14	42.72		1421		16.84	33.32	276	1523	376		72.9
Coeff. of Var. (%)	5002	3.1		4.0		7.5	6.2		6.5		2.6	3.1	17.1	4.5	12.5		9.8
Mean LSD (0.05)	5004	12.1		517		0.11	3.36		116		0.54	1.17	60	82	60		8.2
Mean LSD (0.01)	5005	15.9		683		0.14	4.43		153		0.71	1.55	79	108	79		10.9
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Scandia MN   Bolters based upon 60,000 seed per acre.   Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.   Trial # = 198308

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 14. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Argyle MN

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	347.2	100	10797	101	0.83	51.96	100	1617	101	18.19	31.07	156	1685	137	0	66.4
BTS 8500	122	336.3	97	10578	99	0.89	48.94	94	1537	96	17.71	31.48	188	1731	165	0	61.5
BTS 8524	127	317.8	92	11641	108	0.91	43.78	85	1603	100	16.80	36.66	192	1790	160	0	67.9
BTS 8606	132	335.6	97	9929	92	0.77	48.72	94	1442	90	17.55	29.59	164	1536	134	0	64.5
BTS 8629	115	337.9	97	11111	103	0.80	49.36	95	1625	101	17.69	32.86	193	1472	157	0	64.9
BTS 8735	123	336.8	97	9710	90	0.74	49.07	95	1413	88	17.58	28.89	158	1493	120	0	61.5
BTS 8749	118	352.1	102	10625	99	0.94	53.31	103	1618	101	18.54	29.98	172	1650	229	0	57.1
BTS 8767	129	342.5	99	11100	103	0.86	50.65	98	1641	102	17.98	32.41	188	1593	175	0	59.0
BTS 8784	108	349.8	101	9989	93	0.79	52.69	102	1505	94	18.28	28.57	155	1575	139	0	53.1
Crystal 093RR	110	346.5	100	11268	105	0.89	51.75	100	1683	105	18.21	32.52	166	1654	189	0	65.5
Crystal 247RR	121	337.8	97	11035	103	0.84	49.34	95	1613	101	17.73	32.65	180	1649	147	0	66.5
Crystal 355RR	119	354.0	102	10673	99	0.90	53.87	104	1621	101	18.60	30.19	181	1638	197	0	61.1
Crystal 572RR	124	356.6	103	10325	96	0.88	54.58	105	1580	98	18.71	28.96	182	1523	209	0	63.7
Crystal 574RR	104	340.2	98	10897	101	0.87	50.00	97	1605	100	17.88	31.93	192	1650	167	0	64.7
Crystal 578RR	103	338.1	98	11459	107	0.86	49.42	95	1675	104	17.77	33.87	191	1697	150	0	66.8
Crystal 684RR	133	330.5	95	10547	98	0.92	47.32	91	1512	94	17.44	31.89	203	1753	172	0	60.6
Crystal 793RR	111	343.7	99	11616	108	0.79	50.98	98	1723	107	17.98	33.80	170	1501	154	0	60.5
Crystal 796RR	243	343.0	99	12127	113	0.87	50.78	98	1791	112	18.03	35.47	189	1666	167	0	74.9
Hilleshög HM4302RR	101	332.0	96	9544	89	0.91	47.73	92	1375	86	17.51	28.66	219	1650	189	0	46.7
Hilleshög HM4448RR	109	333.8	96	11362	106	0.84	48.22	93	1645	103	17.53	33.96	179	1613	156	0	63.4
Hilleshög HM9528RR	112	336.9	97	11185	104	0.84	49.10	95	1628	101	17.69	33.22	183	1527	184	0	61.0
Hilleshög HIL9708	105	345.4	100	11351	106	0.83	51.47	99	1692	105	18.11	32.84	181	1601	156	0	65.5
Hilleshög HIL9920	106	349.0	101	10019	93	0.86	52.45	101	1507	94	18.31	28.66	150	1721	157	0	62.6
Maribo MA109	120	347.6	100	9836	92	0.77	52.06	100	1480	92	18.15	28.17	169	1566	118	0	51.6
Maribo MA504	113	326.5	94	10999	102	0.79	46.18	89	1560	97	17.11	33.61	179	1496	149	0	64.2
Maribo MA717	126	337.5	97	11588	108	0.78	49.27	95	1693	106	17.66	34.30	160	1582	127	0	59.7
SX Bronco RR	128	345.4	100	10391	97	0.94	51.47	99	1552	97	18.22	30.05	202	1690	208	0	48.8
SX Canyon RR	102	343.0	99	10620	99	0.81	50.79	98	1573	98	17.96	30.94	168	1557	154	0	65.3
SX Marathon RR	125	336.7	97	10241	95	0.85	49.04	95	1488	93	17.69	30.50	166	1609	175	0	50.9
SV RR265	131	343.7	99	10331	96	0.82	51.00	98	1535	96	18.01	30.01	158	1562	169	0	56.9
SV RR268	116	337.8	97	10868	101	0.81	49.34	95	1588	99	17.70	32.16	167	1639	130	0	60.4
SV RR333	117	346.3	100	10912	102	0.79	51.71	100	1628	101	18.11	31.51	160	1566	140	0	60.8
SV RR351	107	338.3	98	8648	81	0.83	49.49	96	1261	79	17.75	25.63	161	1628	156	0	55.8
SV RR371	114	342.7	99	9892	92	0.82	50.72	98	1471	92	17.96	28.69	160	1599	153	0	49.5

Table 14 cont

Experimental Trial (Comm status)																	
BTS 8815	202	349.6	101	11731	109	0.80	52.67	102	1770	110	18.27	33.52	157	1635	133	0	66.7
BTS 8882	228	352.6	102	12063	112	0.87	53.52	103	1834	114	18.51	34.16	198	1677	165	0	59.9
Crystal 803RR	227	362.7	105	11804	110	0.77	56.40	109	1837	114	18.90	32.49	143	1529	144	0	71.0
Crystal 804RR	237	341.1	98	11072	103	0.91	50.25	97	1633	102	17.96	32.40	196	1686	188	0	60.7
Crystal 808RR	240	335.0	97	12525	117	0.83	48.49	94	1811	113	17.57	37.45	197	1664	132	0	67.1
SX 1887	238	355.0	102	10501	98	0.81	54.17	105	1605	100	18.53	29.48	140	1626	143	0	60.3
SX 1888	236	330.6	95	10356	96	0.74	47.25	91	1479	92	17.26	31.37	148	1480	127	0	62.0
SV 285	241	352.3	102	11074	103	0.79	53.42	103	1684	105	18.40	31.39	147	1600	136	0	53.9
SV 289	223	353.5	102	10185	95	0.80	53.77	104	1552	97	18.46	28.81	150	1605	142	0	49.5
SV RR375	204	348.1	100	11333	106	0.86	52.23	101	1701	106	18.26	32.47	174	1682	167	0	59.9
Comm Benchmark Mean		346.6		10739		0.86	51.81		1604		18.19	30.99	175	1665	161		59.1
Trial Mean	5001	340.2		10574		0.84	50.02		1555		17.86	31.06	177	1617	161		59.2
Coeff. of Var. (%)	5002	1.8		4.8		4.1	3.4		5.6		1.6	4.5	9.0	3.0	10.6		11.8
Mean LSD (0.05)	5004	9.3		786		0.05	2.60		135		0.44	2.15	24	72	26		8.3
Mean LSD (0.01)	5005	12.3		1041		0.07	3.44		179		0.59	2.85	32	96	34		10.9
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Argyle MN — Bolters based upon 60,000 seed per acre. — Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 198309

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 15. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Kennedy MN

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	327.5	100	9276	97	1.06	46.48	99	1314	97	17.40	28.43	161	1636	326	0	67.6
BTS 8500	122	324.1	99	10101	106	1.12	45.51	97	1421	105	17.30	31.15	183	1729	342	0	63.4
BTS 8524	127	307.2	94	10644	112	1.09	40.82	87	1413	104	16.47	34.65	202	1800	289	0	65.1
BTS 8606	132	326.1	99	10302	108	1.09	46.09	99	1454	107	17.38	31.66	188	1671	333	0	60.7
BTS 8629	115	321.0	98	10674	112	1.15	44.65	96	1486	110	17.19	33.22	162	1508	429	0	59.4
BTS 8735	123	323.5	99	10353	109	0.95	45.35	97	1447	107	17.10	32.10	174	1469	284	0	59.3
BTS 8749	118	322.4	98	9409	99	1.17	45.06	96	1314	97	17.26	29.25	174	1743	376	0	49.7
BTS 8767	129	326.6	99	9785	103	1.07	46.24	99	1384	102	17.40	29.97	168	1691	322	0	64.7
BTS 8784	108	334.9	102	9563	100	0.94	48.53	104	1392	103	17.64	28.47	148	1490	274	0	52.8
Crystal 093RR	110	337.0	103	10286	108	0.97	49.13	105	1492	110	17.79	30.76	140	1566	285	0	72.1
Crystal 247RR	121	322.3	98	10093	106	0.96	45.02	96	1410	104	17.11	31.27	178	1693	233	0	60.8
Crystal 355RR	119	335.1	102	8800	92	1.08	48.58	104	1274	94	17.81	26.36	151	1758	318	0	74.6
Crystal 572RR	124	348.4	106	10639	112	0.99	52.30	112	1594	118	18.39	30.60	133	1503	321	0	68.6
Crystal 574RR	104	324.7	99	10003	105	1.04	45.69	98	1404	104	17.32	30.88	171	1747	286	0	67.8
Crystal 578RR	103	323.7	99	10294	108	0.98	45.42	97	1442	106	17.15	31.91	185	1660	248	0	66.9
Crystal 684RR	133	327.2	100	10460	110	0.99	46.40	99	1479	109	17.37	32.05	194	1694	248	0	60.8
Crystal 793RR	111	336.6	102	10702	112	0.94	49.00	105	1557	115	17.76	31.79	142	1436	294	0	62.1
Crystal 796RR	243	317.8	97	12010	126	1.02	43.79	94	1658	122	16.86	37.98	174	1701	275	0	77.1
Hilleshög HM4302RR	101	317.5	97	8898	93	0.94	43.69	93	1225	90	16.82	28.01	187	1677	220	0	55.8
Hilleshög HM4448RR	109	326.3	99	10525	110	0.92	46.14	99	1488	110	17.24	32.26	155	1529	254	0	64.8
Hilleshög HM9528RR	112	321.3	98	10175	107	0.91	44.74	96	1418	105	16.97	31.64	172	1560	231	0	63.4
Hilleshög HIL9708	105	325.0	99	10581	111	1.08	45.77	98	1493	110	17.35	32.43	171	1585	353	0	68.0
Hilleshög HIL9920	106	334.2	102	9952	104	1.03	48.34	103	1435	106	17.75	29.87	172	1679	288	0	67.3
Maribo MA109	120	325.6	99	8344	87	0.93	45.95	98	1185	88	17.23	25.43	154	1557	252	0	43.5
Maribo MA504	113	321.4	98	10616	111	0.92	44.76	96	1480	109	16.99	33.01	180	1577	221	0	69.9
Maribo MA717	126	324.8	99	9855	103	0.92	45.72	98	1389	103	17.18	30.23	156	1533	247	0	61.9
SX Bronco RR	128	328.5	100	9703	102	1.03	46.76	100	1383	102	17.49	29.39	165	1674	291	0	60.6
SX Canyon RR	102	325.2	99	9836	103	1.04	45.84	98	1389	103	17.30	30.19	145	1560	340	0	63.5
SX Marathon RR	125	336.1	102	9876	104	0.92	48.87	105	1435	106	17.75	29.39	134	1589	246	0	56.5
SV RR265	131	325.0	99	9756	102	0.99	45.77	98	1378	102	17.26	29.89	167	1666	267	0	60.6
SV RR268	116	332.5	101	9663	101	0.99	47.86	102	1388	103	17.58	29.21	147	1590	292	0	55.1
SV RR333	117	330.5	101	9810	103	1.04	47.31	101	1410	104	17.62	29.45	143	1588	339	0	64.3
SV RR351	107	341.5	104	9957	104	0.99	50.38	108	1459	108	18.07	29.45	141	1553	304	0	62.0
SV RR371	114	324.5	99	9629	101	0.94	45.64	98	1358	100	17.20	29.49	175	1576	247	0	52.9

Table 15 cont

Experimental Trial (Comm status)																	
BTS 8815	202	328.2	100	9564	100	1.00	46.67	100	1367	101	17.41	29.26	154	1699	265	0	62.6
BTS 8882	228	328.6	100	10225	107	1.08	46.77	100	1446	107	17.48	31.41	173	1717	318	0	47.1
Crystal 803RR	227	336.9	103	9807	103	1.12	49.08	105	1413	104	17.95	29.34	151	1572	410	0	73.9
Crystal 804RR	237	330.6	101	10548	111	1.03	47.33	101	1492	110	17.54	32.41	191	1702	269	0	60.6
Crystal 808RR	240	332.9	101	11134	117	0.96	47.95	103	1595	118	17.57	33.66	165	1642	232	0	70.2
SX 1887	238	339.6	103	10122	106	0.95	49.85	107	1484	110	17.91	29.99	142	1544	265	0	60.0
SX 1888	236	328.9	100	10261	108	1.23	46.86	100	1461	108	17.62	31.36	140	1617	505	0	56.8
SV 285	241	341.8	104	11122	117	0.90	50.44	108	1621	120	17.91	33.04	139	1594	209	0	61.6
SV 289	223	336.5	102	9194	96	0.96	48.99	105	1330	98	17.78	27.47	133	1576	280	0	45.5
SV RR375	204	326.7	99	9848	103	1.13	46.24	99	1367	101	17.44	30.86	139	1669	400	0	65.3
Comm Benchmark Mean		328.4		9537		1.09	46.73		1354		17.51	29.14	163	1721	333		63.8
Trial Mean	5001	327		9922		1.01	46.32		1405		17.36	30.37	165	1623	292		61.2
Coeff. of Var. (%)	5002	2.9		6.8		14.7	5.6		8.4		2.5	5.9	14.7	4.8	37.0		11.2
Mean LSD (0.05)	5004	11.1		833		0.17	3.10		145		0.53	2.27	28	93	123		8.3
Mean LSD (0.01)	5005	14.7		1100		0.22	4.09		192		0.70	3.00	36	123	162		10.9
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Kennedy MN Bolters based upon 60,000 seed per acre. Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. Trial # = 198310

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 16. 2019 Performance of Approved RR Varieties - ACSC Official Trials

Bathgate ND

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8337	130	346.5	103	10641	105	0.81	51.75	105	1588	108	18.13	30.71	100	1473	198	0	70.9
BTS 8500	122	331.4	98	10398	103	0.89	47.57	96	1494	101	17.46	31.42	121	1559	231	0	67.9
BTS 8524	127	326.0	96	10725	106	0.87	46.06	93	1516	103	17.18	32.92	119	1570	215	0	67.0
BTS 8606	132	336.2	99	10074	100	0.85	48.90	99	1465	99	17.67	30.03	105	1553	211	0	65.6
BTS 8629	115	332.3	98	11111	110	0.78	47.81	97	1597	108	17.39	33.42	92	1421	195	0	67.1
BTS 8735	123	330.3	98	10784	107	0.82	47.26	96	1539	104	17.34	32.69	118	1397	224	0	64.6
BTS 8749	118	332.4	98	10279	102	0.91	47.85	97	1479	100	17.53	30.92	113	1662	222	21	55.1
BTS 8767	129	337.3	100	10437	103	0.85	49.20	100	1524	103	17.71	30.89	116	1584	196	0	71.8
BTS 8784	108	342.5	101	10023	99	0.83	50.64	103	1483	101	17.96	29.25	99	1392	240	0	56.0
Crystal 093RR	110	342.2	101	10703	106	0.84	50.58	102	1584	107	17.95	31.17	100	1501	220	0	76.1
Crystal 247RR	121	334.7	99	9769	97	0.81	48.48	98	1417	96	17.54	29.21	124	1476	190	0	65.1
Crystal 355RR	119	336.4	100	8961	89	0.91	48.94	99	1301	88	17.72	26.70	118	1580	242	0	76.0
Crystal 572RR	124	340.6	101	10290	102	0.82	50.11	101	1511	102	17.85	30.27	90	1440	219	0	67.7
Crystal 574RR	104	333.5	99	10486	104	0.89	48.15	97	1517	103	17.56	31.41	109	1563	235	0	74.3
Crystal 578RR	103	335.1	99	10372	103	0.81	48.58	98	1502	102	17.56	31.01	104	1549	179	0	71.7
Crystal 684RR	133	334.2	99	10939	108	0.88	48.34	98	1579	107	17.59	32.77	110	1627	214	0	56.8
Crystal 793RR	111	334.6	99	10136	100	0.80	48.45	98	1468	100	17.53	30.24	95	1433	206	0	62.9
Crystal 796RR	243	332.8	98	10563	105	0.86	47.85	97	1526	103	17.51	31.60	118	1497	229	0	83.9
Hilleshög HM4302RR	101	325.6	96	9404	93	0.85	45.95	93	1327	90	17.13	28.84	126	1599	191	0	52.2
Hilleshög HM4448RR	109	337.7	100	10507	104	0.82	49.32	100	1533	104	17.71	31.12	103	1445	216	0	67.1
Hilleshög HM9528RR	112	333.0	99	10098	100	0.85	48.01	97	1458	99	17.50	30.31	105	1537	211	0	65.1
Hilleshög HIL9708	105	335.1	99	10096	100	0.84	48.58	98	1465	99	17.59	30.12	117	1510	205	0	76.0
Hilleshög HIL9920	106	344.8	102	10354	102	0.84	51.29	104	1536	104	18.08	30.09	102	1585	196	0	71.4
Maribo MA109	120	341.8	101	9170	91	0.87	50.47	102	1354	92	17.96	26.85	101	1607	211	0	58.2
Maribo MA504	113	335.9	99	11196	111	0.81	48.82	99	1626	110	17.61	33.36	106	1476	200	0	62.5
Maribo MA717	126	342.6	101	11126	110	0.85	50.67	103	1642	111	17.98	32.53	100	1503	227	0	76.0
SX Bronco RR	128	341.3	101	10281	102	0.88	50.30	102	1516	103	17.95	30.17	122	1616	210	0	60.1
SX Canyon RR	102	334.7	99	10166	101	0.79	48.48	98	1471	100	17.52	30.39	97	1471	185	0	64.6
SX Marathon RR	125	329.6	98	9914	98	0.87	47.06	95	1416	96	17.35	30.02	123	1536	221	0	58.5
SV RR265	131	339.7	101	10508	104	0.80	49.88	101	1539	104	17.78	31.00	104	1518	175	0	72.1
SV RR268	116	333.0	99	10277	102	0.81	47.99	97	1485	101	17.45	30.82	99	1512	189	0	63.1
SV RR333	117	333.3	99	9951	98	0.81	48.08	97	1437	97	17.47	29.83	95	1527	188	0	74.4
SV RR351	107	332.4	98	10777	107	0.83	47.83	97	1551	105	17.45	32.41	113	1508	201	0	65.8
SV RR371	114	333.3	99	9412	93	0.80	48.09	97	1361	92	17.46	28.21	90	1522	179	0	57.9

Table 16 cont

Experimental Trial (Comm status)																	
BTS 8815	202	345.6	102	9672	96	0.80	51.61	105	1449	98	18.08	27.87	92	1540	181	0	74.9
BTS 8882	228	334.2	99	10208	101	0.88	48.27	98	1477	100	17.60	30.45	116	1571	225	0	63.0
Crystal 803RR	227	343.0	101	10542	104	0.85	50.88	103	1560	106	17.99	30.80	98	1484	229	0	85.8
Crystal 804RR	237	336.9	100	9922	98	0.89	49.05	99	1445	98	17.74	29.44	127	1506	244	0	59.6
Crystal 808RR	240	330.0	98	9129	90	0.96	47.05	95	1301	88	17.47	27.62	150	1580	264	0	76.3
SX 1887	238	340.5	101	10438	103	0.83	50.10	101	1541	104	17.84	30.60	109	1534	200	0	68.9
SX 1888	236	345.4	102	10778	107	0.77	51.54	104	1611	109	18.03	31.10	100	1415	188	0	63.8
SV 285	241	347.9	103	10122	100	0.81	52.30	106	1523	103	18.19	28.97	110	1511	187	0	62.9
SV 289	223	339.1	100	9544	94	0.81	49.71	101	1401	95	17.76	28.07	104	1535	184	0	59.1
SV RR375	204	339.2	100	10853	107	0.81	49.73	101	1591	108	17.77	31.94	101	1485	194	0	67.1
Comm Benchmark Mean		338.0		10105		0.87	49.39		1475		17.77	29.93	112	1562	220		67.3
Trial Mean	5001	335.3		10218		0.84	48.64		1482		17.61	30.48	107	1529	208		65.2
Coeff. of Var. (%)	5002	2.3		5.0		6.2	4.5		6.1		2.1	4.8	18.9	4.4	12.7		14.6
Mean LSD (0.05)	5004	9.8		652		0.07	2.72		114		0.46	1.85	24	83	33		11.6
Mean LSD (0.01)	5005	12.9		861		0.09	3.59		151		0.61	2.45	31	110	44		15.3
Sig Lvl	5007	**		**		**	**		**		**	**	**	**	**		**

* 2019 Data from Bathgate ND — Bolters based upon 60,000 seed per acre. — Created 11/22/2019

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 198313

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 17. 2019 Performance of Approved Varieties - Conventional Official Trials

3 sites - All Characters

Unadjusted		Rec/T	Rec/T	Rec/A	Rec/A	Loss	Rev/T	Rev/T	Rev/A	Rev/A	Sugar	Yield	Na	K	AmN	Bolter	Emerg.
Description @	Code	lbs.	%Mean	lbs.	%Mean	Mol %	$ ++	%Mean	$ ++	%Mean	%	T/A	ppm	ppm	ppm	/Ac	%
Previous Approved																	
Crystal 620	807	310.5	100	10403	104	1.07	41.74	99	1394	103	16.59	33.69	271	1599	302	0	54.5
Crystal 840	802	301.7	97	9916	99	1.15	39.30	93	1288	95	16.23	33.11	317	1665	329	0	52.5
Crystal R761	806	299.3	96	10742	107	1.21	38.62	92	1375	102	16.18	35.97	359	1784	334	0	61.4
Hilleshög HM3035Rz	803	317.8	102	9439	94	1.02	43.77	104	1294	96	16.91	29.89	239	1526	297	0	72.3
Seedex 8869 Cnv	801	307.4	99	10388	103	1.02	40.88	97	1374	101	16.40	33.94	339	1553	258	0	63.7
SV 48777	805	322.8	103	10342	103	0.94	45.18	107	1452	107	17.08	31.83	236	1524	239	0	63.5
Newly Approved																	
Crystal 950	804	308.6	99	10719	107	1.06	41.21	98	1430	106	16.49	34.66	273	1591	295	0	62.2
Benchmark Mean		316.0		10330		1.08	44.35		1427		17.07	32.41	251	1600	314		65.9
Trial Mean		312.0		10047		1.08	42.16		1354		16.68	32.27	287	1616	302		62.1
Coeff. of Var. (%)		3.6		5.7		7.1	7.5		8.0		3.1	5.4	25.7	4.0	13.7		10.8
Mean LSD (0.05)		17.6		682		0.09	4.90		142		0.88	2.00	100	90	54		6.9
Mean LSD (0.01)		24.0		928		0.12	6.67		194		1.20	2.73	136	123	73		9.4
Sig Lvl		**		**		**	**		**		*	**	**	**	*		**

* 2019 Data from 3 sites

%Mean = percentage of trial mean.

@ Some varieties not approved for sale. Refer to approval list for approval status.

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Created 11/22/2019

Trial # = 19ACSConB

Table 18. 2019 Performance of Approved Varieties - Conventional Official Trials

Grand Forks ND - All Characters

Unadjusted		Rec/T	Rec/T	Rec/A	Rec/A	Loss	Rev/T	Rev/T	Rev/A	Rev/A	Sugar	Yield	Na	K	AmN	Bolter	Emerg.
Description @	Code	lbs.	%Mean	lbs.	%Mean	Mol %	$ ++	%Mean	$ ++	%Mean	%	T/A	ppm	ppm	ppm	/Ac	%
Previous Approved																	
Crystal 620	807	291.9	98	10800	103	1.06	36.55	96	1365	102	15.63	37.28	376	1569	258	0	49.0
Crystal 840	802	288.1	97	10474	100	1.13	35.51	93	1287	96	15.53	36.90	441	1679	266	0	43.0
Crystal R761	806	268.9	91	11146	106	1.26	30.15	79	1251	93	14.72	40.76	560	1830	292	0	49.4
Hilleshög HM3035Rz	803	306.7	103	9855	94	1.01	40.68	107	1306	98	16.33	32.91	319	1525	267	0	55.0
Seedex 8869 Cnv	801	286.1	96	10600	101	1.10	34.95	92	1292	97	15.41	37.11	448	1592	262	0	52.0
SV 48777	805	303.6	102	10890	104	0.90	39.83	105	1440	108	16.09	35.21	302	1545	173	0	54.7
Newly Approved																	
Crystal 950	804	298.6	101	11345	108	1.03	38.42	101	1444	108	15.97	38.03	356	1592	250	0	48.9
Benchmark Mean		298.8		10623		1.11	40.38		1399		16.39	34.78	364	1639	287		55.5
Trial Mean		297.1		10498		1.10	38.01		1338		15.95	35.43	392	1648	268		51.4
Coeff. of Var. (%)		3.9		5.4		7.0	8.5		7.1		3.4	6.2	16.6	3.9	12.3		14.5
Mean LSD (0.05)		18.7		910		0.13	5.19		158		0.86	3.15	109	97	55		11.3
Mean LSD (0.01)		25.2		1226		0.17	7.01		214		1.16	4.22	148	130	75		15.1
Sig Lvl		**		**		**	**		**		**	**	**	**	**		ns

* 2019 Data from Grand Forks ND

%Mean = percentage of trial mean.

@ Some varieties not approved for sale. Refer to approval list for approval status.

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Created 11/18/2019

Trial # = 198207

Table 19. 2019 Performance of Approved Varieties - Conventional Official Trials

Scandia MN - All Characters

Unadjusted		Rec/T	Rec/T	Rec/A	Rec/A	Loss	Rev/T	Rev/T	Rev/A	Rev/A	Sugar	Yield	Na	K	AmN	Bolter	Emerg.
Description @	Code	lbs.	%Mean	lbs.	%Mean	Mol %	$ ++	%Mean	$ ++	%Mean	%	T/A	ppm	ppm	ppm	/Ac	%
Previous Approved																	
Crystal 620	807	314.2	100	9613	104	1.24	42.76	100	1307	104	16.95	30.72	284	1674	418	0	0.0
Crystal 840	802	302.7	96	9469	103	1.27	39.57	93	1237	98	16.39	31.13	327	1648	423	0	0.0
Crystal R761	806	311.3	99	9962	108	1.43	41.95	98	1339	106	16.98	32.09	375	1853	480	0	0.0
Hilleshög HM3035Rz	803	322.5	103	8926	97	1.17	45.08	105	1246	99	17.31	27.76	273	1509	407	0	0.0
Seedex 8869 Cnv	801	313.1	100	9492	103	1.17	42.47	99	1290	102	16.84	30.56	433	1523	346	0	0.0
SV 48777	805	323.2	103	9070	98	1.10	45.29	106	1270	101	17.27	27.97	283	1475	349	0	0.0
Newly Approved																	
Crystal 950	804	309.7	99	9821	106	1.25	41.51	97	1315	104	16.74	31.46	317	1597	424	0	0.0
Benchmark Mean		319.6		9666		1.20	46.17		1367		17.52	29.63	257	1587	417		0.0
Trial Mean		314.1		9235		1.23	42.75		1260		16.93	29.32	325	1604	405		0.0
Coeff. of Var. (%)		3.7		3.7		8.0	7.6		6.7		3.1	3.3	32.2	4.0	14.5		0.0
Mean LSD (0.05)		18.6		560		0.15	5.17		138		0.84	1.52	161	103	85		0.0
Mean LSD (0.01)		25.1		758		0.20	6.98		187		1.14	2.04	216	138	114		0.0
Sig Lvl		**		**		*	**		**		**	**	**	**	*		0.0

* 2019 Data from Scandia MN

%Mean = percentage of trial mean.

@ Some varieties not approved for sale. Refer to approval list for approval status.

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Created 11/18/2019

Trial # = 198208

Table 20. 2019 Performance of Approved Varieties - Conventional Official Trials

Bathgate ND - All Characters

Unadjusted		Rec/T	Rec/T	Rec/A	Rec/A	Loss	Rev/T	Rev/T	Rev/A	Rev/A	Sugar	Yield	Na	K	AmN	Bolter	Emerg.
Description @	Code	lbs.	%Mean	lbs.	%Mean	Mol %	$ ++	%Mean	$ ++	%Mean	%	T/A	ppm	ppm	ppm	/Ac	%
Previous Approved																	
Crystal 620	807	327.2	101	10825	104	0.89	46.39	102	1539	105	17.25	32.98	131	1558	229	0	0.0
Crystal 840	802	314.1	97	9830	94	1.05	42.73	94	1331	91	16.76	31.46	201	1669	296	0	0.0
Crystal R761	806	317.6	98	11158	107	0.96	43.70	96	1541	105	16.83	35.00	155	1673	250	0	0.0
Hilleshög HM3035Rz	803	325.0	100	9513	91	0.85	45.76	100	1348	92	17.11	29.04	122	1544	209	0	0.0
Seedex 8869 Cnv	801	322.7	99	10925	105	0.80	45.15	99	1525	104	16.95	33.93	122	1535	167	0	0.0
SV 48777	805	340.6	105	11036	106	0.81	50.12	110	1623	111	17.84	32.47	123	1548	174	0	0.0
Newly Approved																	
Crystal 950	804	317.1	98	10989	106	0.89	43.58	95	1509	103	16.75	34.71	162	1585	210	0	0.0
Benchmark Mean		329.4		10734		0.91	46.48		1523		17.29	32.78	132	1578	241		0.0
Trial Mean		324.7		10408		0.91	45.70		1465		17.15	32.05	145	1595	232		0.0
Coeff. of Var. (%)		3.2		6.7		5.6	6.2		9.1		2.8	5.2	18.6	3.8	10.6		0.0
Mean LSD (0.05)		15.9		998		0.08	4.44		194		0.76	2.39	44	89	42		0.0
Mean LSD (0.01)		21.5		1341		0.11	5.97		261		1.02	3.20	60	120	57		0.0
Sig Lvl		*		**		**	*		**		*	**	**	**	**		0.0

* 2019 Data from Bathgate ND

%Mean = percentage of trial mean.

@ Some varieties not approved for sale. Refer to approval list for approval status.

++ Revenue estimates are based on a $44.38 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Created 11/18/2019

Trial # = 198213

Table 21.

Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2020

Description	Approval Status	Rec/Ton 2018	Rec/Ton 2019	Rec/Ton 2 Yr	Rec/Ton % Bench	Rev/Acre 2018	Rev/Acre 2019	Rev/Acre 2 Yr	Rev/Acre % Bench	R/T + $/A Bench	Cercospora Rating + 2017	Cercospora Rating + 2018	Cercospora Rating + 2019	Cercospora Rating + 2 Yr Mean	3 Yr Mean
Previously Approved (3 Yr)															**<=5.30**
BTS 8337	Approved	356.8	326.6	341.7	102.2	1619	1442	1531	102.8	205.0	4.36	4.64	4.40	4.52	4.47
BTS 8500	Approved	343.7	310.9	327.3	97.9	1719	1418	1569	105.3	203.2	4.29	4.40	4.00	4.20	4.23
BTS 8524	Approved	333.6	304.0	318.8	95.4	1658	1408	1533	102.9	198.3	4.38	4.50	4.52	4.51	4.47
BTS 8606	Approved	349.8	315.9	332.9	99.6	1684	1404	1544	103.7	203.2	4.73	4.80	4.69	4.74	4.74
BTS 8629	Approved	343.2	309.0	326.1	97.6	1752	1445	1599	107.3	204.9	4.29	4.52	4.66	4.59	4.49
BTS 8735	Approved	354.1	311.8	333.0	99.6	1689	1413	1551	104.1	203.7	4.22	4.21	4.15	4.18	4.19
BTS 8749	Approved	347.6	317.8	332.7	99.5	1596	1393	1495	100.3	199.9	4.05	4.10	3.95	4.02	4.03
BTS 8767	Approved	344.7	317.4	331.1	99.0	1664	1447	1556	104.4	203.5	4.16	4.32	4.26	4.29	4.24
BTS 8784	Approved	358.0	327.3	342.7	102.5	1667	1409	1538	103.3	205.8	3.65	3.73	3.84	3.78	3.74
Crystal 093RR	Approved	356.0	324.8	340.4	101.8	1666	1470	1568	105.3	207.1	4.49	4.88	5.09	4.98	4.82
Crystal 247RR	Approved	345.4	311.9	328.7	98.3	1669	1330	1500	100.7	199.0	4.55	4.54	4.50	4.52	4.53
Crystal 355RR	Approved	350.1	325.2	337.7	101.0	1524	1321	1423	95.5	196.5	4.36	4.52	4.68	4.60	4.52
Crystal 572RR	Approved	354.6	331.7	343.2	102.7	1718	1476	1597	107.2	209.9	4.27	4.45	4.68	4.56	4.47
Crystal 574RR	Approved	342.5	313.3	327.9	98.1	1733	1436	1585	106.4	204.5	4.35	4.42	4.28	4.35	4.35
Crystal 578RR	Approved	346.5	314.3	330.4	98.9	1645	1417	1531	102.8	201.6	4.91	4.74	4.64	4.69	4.76
Crystal 684RR	Approved	342.3	310.3	326.3	97.6	1756	1429	1593	106.9	204.5	4.34	4.41	4.12	4.27	4.29
Crystal 793RR	Approved	356.7	325.5	341.1	102.1	1804	1555	1680	112.8	214.9	3.93	4.26	4.04	4.15	4.08
Crystal 796RR	Approved	345.4	315.0	330.2	98.8	1743	1530	1637	109.9	208.7	4.85	4.74	4.74	4.74	4.78
Hilleshög HM4302RR	Approved	343.8	311.3	327.6	98.0	1572	1271	1422	95.4	193.4	3.93	4.26	3.93	4.09	4.04
Hilleshög HM4448RR	Not Approved	346.8	315.5	331.2	99.1	1720	1455	1588	106.6	205.7	5.28	5.26	5.48	5.37	5.34
Hilleshög HM9528RR	Approved	344.5	317.7	331.1	99.1	1632	1455	1544	103.6	202.7	4.99	4.79	4.93	4.86	4.90
Hilleshög HIL9708	Approved	346.9	316.3	331.6	99.2	1684	1433	1559	104.6	203.8	4.61	4.71	4.96	4.83	4.76
Hilleshög HIL9920	Approved	355.2	325.2	340.2	101.8	1695	1430	1563	104.9	206.7	4.89	4.79	4.95	4.87	4.88
Maribo MA109	Approved	354.3	326.2	340.3	101.8	1522	1321	1422	95.4	197.2	4.14	4.33	4.07	4.20	4.18
Maribo MA504	Approved	343.0	307.1	325.1	97.3	1748	1420	1584	106.3	203.6	5.50	4.98	5.34	5.16	5.27
Maribo MA717	Approved	354.4	319.8	337.1	100.9	1666	1476	1571	105.5	206.3	4.85	4.78	5.11	4.95	4.91
SX Bronco RR	Approved	349.0	321.8	335.4	100.3	1647	1415	1531	102.8	203.1	4.08	4.65	4.77	4.71	4.50
SX Canyon RR	Approved	346.0	319.0	332.5	99.5	1674	1434	1554	104.3	203.8	4.92	4.79	4.58	4.69	4.76
SX Marathon RR	Approved	347.2	318.2	332.7	99.5	1717	1380	1549	104.0	203.5	4.54	5.27	4.79	5.03	4.87
SV RR265	Approved	343.7	319.7	331.7	99.2	1663	1422	1543	103.6	202.8	5.19	4.48	4.28	4.38	4.65
SV RR268	Approved	350.3	319.8	335.1	100.2	1679	1408	1544	103.6	203.9	5.06	4.70	4.82	4.76	4.86
SV RR333	Approved	351.1	322.9	337.0	100.8	1642	1408	1525	102.4	203.2	4.84	4.78	4.49	4.64	4.70
SV RR351	Approved	347.4	320.6	334.0	99.9	1661	1401	1531	102.8	202.7	4.41	4.61	4.90	4.76	4.64
SV RR371	Approved	346.0	320.6	333.3	99.7	1622	1377	1500	100.7	200.4	4.59	4.71	4.34	4.53	4.55

Table 21 cont

Candidates for Approval (2 Yr)																<=5.00	
BTS 8815	Approved		351.1	325.5	338.3	101.2		1670	1458	1564	105.0	206.2	--	4.65	4.61	4.63	--
BTS 8882	Approved		345.3	316.0	330.7	98.9		1709	1445	1577	105.9	204.8	--	4.53	4.18	4.35	--
Crystal 803RR	Approved		352.2	329.5	340.8	102.0		1727	1493	1610	108.1	210.1	--	4.01	3.88	3.95	--
Crystal 804RR	Approved		343.5	319.2	331.3	99.1		1731	1472	1602	107.5	206.7	--	4.42	4.46	4.44	--
Crystal 808RR	Approved		347.8	315.4	331.6	99.2		1771	1456	1614	108.3	207.5	--	4.86	4.78	4.82	--
Hilleshög HIL2230	Not Approved		342.7	316.8	329.8	98.7		1578	1424	1501	100.8	199.5	--	4.71	4.91	4.81	--
Hilleshög HIL2233	Not Approved		351.4	324.6	338.0	101.1		1705	1508	1607	107.9	209.0	--	4.87	5.26	5.06	--
SX 1887	Approved		348.6	326.6	337.6	101.0		1659	1421	1540	103.4	204.4	--	4.89	4.89	4.89	--
SX 1888	Approved		349.3	323.2	336.2	100.6		1698	1475	1587	106.5	207.1	--	4.92	4.89	4.90	--
SV 285	Approved		346.3	324.2	335.3	100.3		1633	1422	1528	102.6	202.9	--	4.52	4.84	4.68	--
SV 289	Approved		351.3	324.2	337.8	101.1		1689	1376	1533	102.9	203.9	--	4.65	4.59	4.62	--
SV RR375	Approved		347.2	323.6	335.4	100.3		1648	1431	1540	103.4	203.7	5.08	4.96	4.11	4.54	4.72
Benchmark Varieties		2017	2018	2019			2017	2018	2019								
Hilleshög HM4302RR	Benchmark	334.0					1597										
BTS 80RR52	Benchmark	334.2	346.5				1699	1536									
Crystal 101RR (Check)	Benchmark	329.3	337.8	309.5			1718	1602	1355								
Crystal 355RR	Benchmark	340.0	350.1	325.2			1711	1524	1321								
BTS 8572 (Check)	Benchmark		350.7	327.5				1677	1459								
BTS 8337	Benchmark			326.6					1442								
Benchmark mean		334.4	346.3	322.2	334.2		1681	1585	1394	1490							

+ All Cercospora ratings 2017-2019 were adjusted to 1982 basis. Created 11-21-2019

Variety approval criteria include: 1) 2 years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data), 3a) R/T >= 100% of Bench or 3b) R/T >= 97% and R/T + $/A >= 202% of Bench. 3 yrs of data may be considered for initial approval.

Bench for 2019 added Beta 8337 and dropped Beta 80RR52 (Check).

To maintain approval, the 3-year Cercospora rating must not exceed 5.20 (1982 adjusted data).

Table 22.
Projected Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2020

		Rec/Ton		Rev/Acre		R/T +	CR Rating ^^
	Approval ^		%		%	$/A	
Description	Likely	2019	Bench	2019	Bench	Bench	2019
Candidates for Retesting (1 Yr)							
BTS 8927	On Track	337.8	104.8	1583	113.5	218.4	4.35
BTS 8938	On Track	329.2	102.2	1487	106.7	208.8	4.35
BTS 8945	On Track	318.1	98.7	1530	109.7	208.5	4.41
BTS 8958	On Track	317.0	98.4	1470	105.4	203.8	3.66
BTS 8961	On Track	315.7	98.0	1475	105.8	203.8	4.27
BTS 8976	On Track	332.4	103.2	1524	109.3	212.5	3.83
BTS 8985	Not On Track	318.1	98.7	1368	98.1	196.8	4.10
BTS 8989	On Track	326.8	101.4	1523	109.2	210.7	3.93
BTS 8994	Not On Track	317.7	98.6	1413	101.3	199.9	4.13
BTS 8995	On Track	322.3	100.0	1459	104.6	204.7	3.74
Crystal 912RR	On Track	316.1	98.1	1595	114.4	212.5	4.62
Crystal 913RR	On Track	332.5	103.2	1620	116.2	219.4	4.11
Crystal 914RR	Not On Track	311.6	96.7	1388	99.6	196.3	4.52
Crystal 915RR	On Track	320.7	99.5	1466	105.1	204.7	4.41
Crystal 916RR	On Track	318.2	98.8	1575	113.0	211.7	4.26
Crystal 918RR	On Track	322.1	100.0	1460	104.7	204.7	4.14
Hilleshög HIL2315	Not On Track	313.8	97.4	1343	96.3	193.7	4.86
Hilleshög HIL2316	Not On Track	318.6	98.9	1356	97.3	196.1	4.65
Hilleshög HIL2317	On Track	332.2	103.1	1502	107.7	210.8	4.90
Hilleshög HIL2318	Not On Track	317.7	98.6	1364	97.8	196.4	4.34
Hilleshög HIL2319	Not On Track	318.1	98.7	1513	108.5	207.2	5.45
Hilleshög HIL2320	On Track	331.1	102.8	1550	111.2	213.9	4.92
Maribo MA901	On Track	322.1	100.0	1343	96.3	196.3	4.57
Maribo MA902	Not On Track	319.2	99.1	1425	102.2	201.3	4.91
Maribo MA903	Not On Track	321.8	99.9	1520	109.0	208.9	5.25
SX 1894	Not On Track	320.5	99.5	1364	97.8	197.3	5.13
SX 1895	Not On Track	326.5	101.3	1344	96.4	197.7	4.56
SX 1896	Not On Track	314.6	97.6	1306	93.7	191.3	4.93
SX 1897	Not On Track	313.2	97.2	1366	98.0	195.2	4.81
SX 1898	On Track	325.3	101.0	1433	102.8	203.7	4.68
SV 391	Not On Track	313.7	97.4	1421	101.9	199.3	5.07
SV 392	Not On Track	325.1	100.9	1345	96.5	197.4	5.37
SV 393	On Track	325.0	100.9	1387	99.5	200.3	4.94
SV 394	Not On Track	319.9	99.3	1331	95.5	194.7	4.71
Benchmarks							
Crystal 101RR (Check)		309.5	96.1	1355	97.2		
Crystal 355RR		325.2	100.9	1321	94.7		
BTS 8572 (Check)		327.5	101.6	1459	104.6		
BTS 8337		326.6	101.4	1442	103.4		
Benchmark Mean		322.2		1394			

^ Not on Track = not on track for approval. On Track = data is tracking for potential approval. Created 11-21-2019

^^ All Cercospora ratings 2019 were adjusted to 1982 basis.

Full market approval criteria include: 1) 2 years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data),
3a) R/T >= 100% of Bench or 3b) R/T >= 97% and R/T + $/A equal to 202 of Bench.

Bench for 2019 added Beta 8337 and dropped Beta 80RR52 (Check).

	Table 23													
	Calculation for Approval of Sugarbeet Varieties for ACSC Aphanomyces Specialty Market for 2020													
Trial		Approval	Root Aph. Rating						Cercospora Rating +					
Yrs	Description	Status	2017	2018	2019	2 Yr	3 Yr		2017	2018	2019	2 Yr	3 Yr	
	Previously Approved (3 Yrs)						**<=4.70**						**<=5.30**	
7	BTS 8337	Approved	3.78	3.74	3.45	3.60	3.66		4.36	4.64	4.40	4.52	4.47	
5	BTS 8500	Approved	4.52	4.43	4.30	4.37	4.42		4.29	4.40	4.00	4.20	4.23	
5	BTS 8524	Approved	4.49	4.08	4.51	4.30	4.36		4.38	4.50	4.52	4.51	4.47	
4	BTS 8629	Approved	4.68	3.89	5.32	4.61	4.63		4.29	4.52	4.66	4.59	4.49	
3	BTS 8735	Approved	4.74	4.00	4.53	4.27	4.42		4.22	4.21	4.15	4.18	4.19	
3	BTS 8749	Approved	3.53	2.79	2.97	2.88	3.10		4.05	4.10	3.95	4.03	4.03	
10	Crystal 093RR	Approved	4.43	4.38	5.22	4.80	4.68		4.49	4.88	5.09	4.99	4.82	
7	Crystal 355RR	Not Approved	4.84	4.42	5.02	4.72	4.76		4.36	4.52	4.68	4.60	4.52	
5	Crystal 574RR	Approved	4.72	4.32	3.99	4.16	4.34		4.35	4.42	4.28	4.35	4.35	
5	Crystal 578RR	Approved	4.56	4.21	4.88	4.55	4.55		4.91	4.74	4.64	4.69	4.76	
4	Crystal 684RR	Approved	4.31	3.83	4.33	4.08	4.16		4.34	4.41	4.12	4.27	4.29	
3	Crystal 793RR	Approved	3.02	3.32	3.72	3.52	3.35		3.93	4.26	4.04	4.15	4.08	
3	Crystal 796RR	Approved	3.11	3.61	3.97	3.79	3.56		4.85	4.74	4.74	4.74	4.78	
6	Hilleshög HM9528RR	Not Approved	5.63	4.22	4.56	4.39	4.80		4.99	4.79	4.93	4.86	4.90	
6	Maribo MA109	Not Approved	5.06	4.38	5.28	4.83	4.91		4.14	4.33	4.07	4.20	4.18	
3	Maribo MA717	Approved	5.31	4.15	4.42	4.29	4.63		4.85	4.78	5.11	4.95	4.91	
4	SX Bronco RR	Not Approved	4.88	4.05	5.38	4.72	4.77		4.08	4.65	4.77	4.71	4.50	
6	SX Canyon RR	Approved	4.33	4.34	4.99	4.67	4.55		4.92	4.79	4.58	4.69	4.76	
4	SV RR268	Approved	4.71	4.21	5.08	4.65	4.67		5.06	4.70	4.82	4.76	4.86	
7	SV RR333	Approved	4.99	4.06	4.70	4.38	4.58		4.84	4.78	4.49	4.64	4.70	
5	SV RR351	Not Approved	4.18	4.50	5.65	5.08	4.78		4.41	4.61	4.90	4.76	4.64	

Table 23 cont

	Candidates for Approval					<=4.40						<=5.00
3	BTS 8767	Approved	4.80	4.28	4.32	4.30	4.47	4.16	4.32	4.26	4.29	4.25
3	BTS 8784	Approved	4.59	4.22	4.38	4.30	4.40	3.65	3.73	3.84	3.79	3.74
4	BTS 8606	Not Approved	4.91	4.43	5.11	4.77	4.82	4.73	4.80	4.69	4.75	4.74
2	BTS 8815	Not Approved		3.97	5.24	4.61			4.65	4.61	4.63	
2	BTS 8882	Not Approved		4.98	5.17	5.08			4.53	4.18	4.36	
8	Crystal 247RR	Not Approved	5.35	5.02	4.84	4.93	5.07	4.55	4.54	4.50	4.52	4.53
5	Crystal 572RR	Not Approved	4.69	4.47	4.98	4.73	4.71	4.27	4.45	4.68	4.57	4.47
2	Crystal 803RR	Approved		3.86	4.45	4.16			4.01	3.88	3.95	
2	Crystal 804RR	Approved		3.58	4.30	3.94			4.42	4.46	4.44	
2	Crystal 808RR	Approved		3.60	3.57	3.59			4.86	4.78	4.82	
2	Hilleshög HIL2230	Not Approved		3.96	4.95	4.46			4.71	4.91	4.81	
2	Hilleshög HIL2233	Not Approved		4.02	4.43	4.23			4.87	5.26	5.07	
9	Hilleshög HM4302RR	Not Approved	6.66	4.65	5.20	4.93	5.50	3.93	4.26	3.93	4.10	4.04
7	Hilleshög HM4448RR	Not Approved	6.29	4.53	4.86	4.70	5.23	5.28	5.26	5.48	5.37	5.34
5	Hilleshög HIL9708	Not Approved	5.94	4.25	4.61	4.43	4.93	4.61	4.71	4.96	4.84	4.76
3	Hilleshög HIL9920	Not Approved	4.94	4.09	5.05	4.57	4.69	4.89	4.79	4.95	4.87	4.88
5	Maribo MA504	Not Approved	6.20	5.30	6.17	5.74	5.89	5.50	4.98	5.34	5.16	5.27
5	SX Marathon RR	Not Approved	4.52	4.72	5.15	4.94	4.80	4.54	5.27	4.79	5.03	4.87
2	SX 1887	Not Approved		4.49	4.67	4.58			4.89	4.89	4.89	
2	SX 1888	Approved		4.03	4.65	4.34			4.92	4.89	4.91	
2	SV 285	Approved		3.98	4.47	4.23			4.52	4.84	4.68	
2	SV 289	Not Approved		4.42	5.30	4.86			4.65	4.59	4.62	
4	SV RR265	Not Approved	5.35	4.16	5.47	4.82	4.99	5.19	4.48	4.28	4.38	4.65
3	SV RR375	Not Approved	4.54	3.83	5.03	4.43	4.47	5.08	4.96	4.11	4.54	4.72
3	SV RR371	Not Approved	4.55	4.51	4.99	4.75	4.68	4.59	4.71	4.34	4.53	4.55
	Approval Criteria new varieties					4.40					5.00	
	Criteria to Maintain Approval						4.70					5.30

+ All Cercospora ratings 2017-2019 were adjusted to 1982 basis. Created 11/25/2019

Aphanomyces approval criteria include: 1) Cercospora rating must not exceed 5.00 (1982 adjusted data), 2) Aph root rating <= 4.40 after 2 years.

3 yrs of data may be considered for initial approval.

To maintain Aphanomyces approval criteria include: 1) Cercospora 3 year mean must not exceed 5.30, 2) Aph root rating <= 4.70 after 3 years.

Table 24

Calculation for Approval of Sugarbeet Varieties for ACSC Rhizoctonia Specialty Market for 2020

	Approval	Disease Index +					Cercospora Rating				
Description	Status	2017	2018	2019	2 Yr Mn	3 Yr Mn	2017	2018	2019	2 Yr Mn	3 Yr Mn
Previously Approved (3 Yr)											
Crystal 355RR	Approved	4.09	3.66	3.67	3.67	3.81	4.36	4.52	4.68	4.60	4.52
Hilleshög HM4302RR	Approved	3.60	3.71	3.97	3.84	3.76	3.93	4.26	3.93	4.10	4.04
Maribo MA109	Approved	3.63	3.69	3.73	3.71	3.68	4.14	4.33	4.07	4.20	4.18
Candidates for Approval (2 Yr)											
BTS 8337	Approved	4.30	4.07	3.62	3.85	4.00	4.36	4.64	4.40	4.52	4.47
BTS 8500	Not Approved	4.57	4.36	4.28	4.32	4.40	4.29	4.40	4.00	4.20	4.23
BTS 8524	Not Approved	4.41	4.23	4.00	4.12	4.21	4.38	4.50	4.52	4.51	4.47
BTS 8606	Not Approved	5.00	4.24	4.60	4.42	4.61	4.73	4.80	4.69	4.75	4.74
BTS 8629	Not Approved	4.21	4.02	3.89	3.96	4.04	4.29	4.52	4.66	4.59	4.49
BTS 8735	Not Approved	4.38	4.12	3.95	4.04	4.15	4.22	4.21	4.15	4.18	4.19
BTS 8749	Approved	3.95	3.88	3.58	3.73	3.80	4.05	4.10	3.95	4.03	4.03
BTS 8767	Not Approved	4.75	4.10	4.14	4.12	4.33	4.16	4.32	4.26	4.29	4.25
BTS 8784	Not Approved	4.64	4.60	4.29	4.45	4.51	3.65	3.73	3.84	3.79	3.74
BTS 8815	Not Approved	--	3.88	4.03	3.96	--	--	4.65	4.61	4.63	--
BTS 8882	Not Approved	--	4.37	4.27	4.32	--	--	4.53	4.18	4.36	--
Crystal 093RR	Not Approved	4.50	4.59	4.14	4.37	4.41	4.49	4.88	5.09	4.99	4.82
Crystal 247RR	Not Approved	4.49	4.56	4.32	4.44	4.46	4.55	4.54	4.50	4.52	4.53
Crystal 572RR	Not Approved	4.47	4.54	4.14	4.34	4.38	4.27	4.45	4.68	4.57	4.47
Crystal 574RR	Not Approved	4.16	4.36	4.45	4.41	4.32	4.35	4.42	4.28	4.35	4.35
Crystal 578RR	Not Approved	4.40	4.30	4.21	4.26	4.30	4.91	4.74	4.64	4.69	4.76
Crystal 684RR	Not Approved	4.57	4.39	4.01	4.20	4.32	4.34	4.41	4.12	4.27	4.29
Crystal 793RR	Not Approved	4.26	4.11	4.18	4.15	4.18	3.93	4.26	4.04	4.15	4.08
Crystal 796RR	Not Approved	4.23	3.97	3.85	3.91	4.02	4.85	4.74	4.74	4.74	4.78
Crystal 803RR	Not Approved	--	4.67	4.54	4.61	--	--	4.01	3.88	3.95	--
Crystal 804RR	Not Approved	--	4.02	3.72	3.87	--	--	4.42	4.46	4.44	--
Crystal 808RR	Not Approved	--	3.83	4.09	3.96	--	--	4.86	4.78	4.82	--
Hilleshög HIL2230	Not Approved	--	4.06	4.48	4.27	--	--	4.71	4.91	4.81	--
Hilleshög HIL2233	Not Approved	--	4.04	3.78	3.91	--	--	4.87	5.26	5.07	--
Hilleshög HIL9708	Approved	4.21	3.71	3.87	3.79	3.93	4.61	4.71	4.96	4.84	4.76
Hilleshög HIL9920	Not Approved	4.48	4.65	4.68	4.67	4.60	4.89	4.79	4.95	4.87	4.88
Hilleshög HM4448RR	Not Approved	4.63	4.38	4.04	4.21	4.35	5.28	5.26	5.48	5.37	5.34
Hilleshög HM9528RR	Not Approved	4.21	4.04	4.10	4.07	4.12	4.99	4.79	4.93	4.86	4.90
Maribo MA504	Not Approved	4.37	4.25	4.69	4.47	4.44	5.50	4.98	5.34	5.16	5.27
Maribo MA717	Not Approved	4.28	4.35	4.15	4.25	4.26	4.85	4.78	5.11	4.95	4.91
SV 285	Not Approved	--	4.35	4.38	4.37	--	--	4.52	4.84	4.68	--
SV 289	Not Approved	--	4.37	4.06	4.22	--	--	4.65	4.59	4.62	--
SV RR265	Not Approved	4.42	4.32	4.25	4.29	4.33	5.19	4.48	4.28	4.38	4.65
SV RR268	Not Approved	4.57	4.21	4.21	4.21	4.33	5.06	4.70	4.82	4.76	4.86
SV RR333	Not Approved	4.44	4.23	4.08	4.16	4.25	4.84	4.78	4.49	4.64	4.70
SV RR351	Not Approved	4.25	4.16	4.09	4.13	4.17	4.41	4.61	4.90	4.76	4.64
SV RR371	Not Approved	4.31	4.19	3.97	4.08	4.16	4.59	4.71	4.34	4.53	4.55
SV RR375	Not Approved	4.25	4.13	4.05	4.09	4.14	5.08	4.96	4.11	4.54	4.72
SX 1887	Not Approved	--	4.16	4.18	4.17	--	--	4.89	4.89	4.89	--
SX 1888	Not Approved	--	4.57	4.19	4.38	--	--	4.92	4.89	4.91	--
SX Bronco RR	Not Approved	4.23	4.73	4.71	4.72	4.56	4.08	4.65	4.77	4.71	4.50
SX Canyon RR	Not Approved	4.51	4.36	3.89	4.13	4.25	4.92	4.79	4.58	4.69	4.76
SX Marathon RR	Not Approved	4.40	4.19	4.36	4.28	4.32	4.54	5.27	4.79	5.03	4.87

Table 24 cont

Susceptible Checks												
RH CK#08 CRYS539RR		4.74	4.68	4.67								
RH CK#21 CRYS768RR		4.66	4.52	4.66								
RH CK#25 HILL4043RR		4.51	4.83	4.66								
RH CK#28 CRYS658RR		4.36	4.02	4.37								
RH CK#29 BETA87RR58		4.79										
RH CK#31 HILL4000RR		4.65										
RH CK#35 SES36812RR		4.71	4.29	4.29								
RH CK#36 BTS85RR02		4.10	4.46	4.56								
RH CK#37 SES36918RR		4.43	4.32	4.75								
RH CK#40 CRYS101RR		4.55	4.50	4.73								
RH CK#45 BTS82RR33		4.73	4.70	4.09								
RH CK#47 SES36272RR		4.62	4.36	4.26								
RH CK#49 CRYS247RR		4.65	4.62	4.16								
RH CK#53 BTS8500				4.30								
Susceptible Hybrid Mean		4.66	4.48	4.49	4.48	4.54					**5.00**	**5.30**
Approval Criteria ++		3.82	3.82	3.82	**3.82**	**3.82**						
Disapproval Criteria						**4.09**						

Rhc and CR ratings were adjusted based upon check performance. Created 11/26/2019

+ Disease Index is based on a scale of 0 (healthy) to 7 (dead).

++ Candidates must have better tolerance than susc. check mean * 80%. To maintain approval, tolerance must be better than susc. check mean * 90%.

Previously approved varieties not meeting current approval standards may be sold in 2019.

Table 25.

2019 Aphanomyces Ratings for Official Trial Entries

Betaseed Nursery - Shakopee, MN

			Unadjusted ^^		Adjusted ^^								
				Shak		Shak							Trial
Chk++	Code	Description		8/27		8/27	2019	2 Yr	3 Yr	2019^^	2018++	2017++	Yrs $$
	573	BTS 8337	---	3.56	---	3.45	3.45	3.59	3.65	3.45	3.74	3.78	7
	540	BTS 8500	---	4.44	---	4.30	4.30	4.37	4.42	4.30	4.43	4.52	5
	515	BTS 8524	---	4.66	---	4.51	4.51	4.29	4.36	4.51	4.08	4.49	5
	574	BTS 8606	---	5.28	---	5.11	5.11	4.77	4.81	5.11	4.43	4.91	4
	504	BTS 8629	---	5.50	---	5.32	5.32	4.61	4.63	5.32	3.89	4.68	4
	518	BTS 8735	---	4.68	---	4.53	4.53	4.27	4.42	4.53	4.00	4.74	3
	513	BTS 8749	---	3.07	---	2.97	2.97	2.88	3.10	2.97	2.79	3.53	3
	510	BTS 8767	---	4.46	---	4.32	4.32	4.30	4.46	4.32	4.28	4.80	3
	524	BTS 8784	---	4.53	---	4.38	4.38	4.30	4.40	4.38	4.22	4.59	3
	580	BTS 8815	---	5.41	---	5.24	5.24	4.60	--	5.24	3.97	--	2
	557	BTS 8882	---	5.34	---	5.17	5.17	5.07	--	5.17	4.98	--	2
	539	BTS 8927	---	4.19	---	4.06	4.06	--	--	4.06	--	--	1
	505	BTS 8938	---	3.87	---	3.75	3.75	--	--	3.75	--	--	1
	531	BTS 8945	---	4.38	---	4.24	4.24	--	--	4.24	--	--	1
	555	BTS 8958	---	5.06	---	4.90	4.90	--	--	4.90	--	--	1
	568	BTS 8961	---	4.02	---	3.89	3.89	--	--	3.89	--	--	1
	545	BTS 8976	---	3.67	---	3.55	3.55	--	--	3.55	--	--	1
	565	BTS 8985	---	4.70	---	4.55	4.55	--	--	4.55	--	--	1
	535	BTS 8989	---	4.93	---	4.77	4.77	--	--	4.77	--	--	1
	527	BTS 8994	---	4.14	---	4.01	4.01	--	--	4.01	--	--	1
	520	BTS 8995	---	4.84	---	4.68	4.68	--	--	4.68	--	--	1
	551	Crystal 093RR	---	5.39	---	5.22	5.22	4.80	4.68	5.22	4.38	4.43	10
	544	Crystal 247RR	---	5.00	---	4.84	4.84	4.93	5.07	4.84	5.02	5.35	8
	569	Crystal 355RR	---	5.19	---	5.02	5.02	4.72	4.76	5.02	4.42	4.84	7
	549	Crystal 572RR	---	5.14	---	4.98	4.98	4.72	4.71	4.98	4.47	4.69	5
	529	Crystal 574RR	---	4.12	---	3.99	3.99	4.16	4.34	3.99	4.32	4.72	5
	532	Crystal 578RR	---	5.04	---	4.88	4.88	4.54	4.55	4.88	4.21	4.56	5
	523	Crystal 684RR	---	4.47	---	4.33	4.33	4.08	4.16	4.33	3.83	4.31	4
	548	Crystal 793RR	---	3.84	---	3.72	3.72	3.52	3.35	3.72	3.32	3.02	3
	501	Crystal 796RR	---	4.10	---	3.97	3.97	3.79	3.56	3.97	3.61	3.11	3
	533	Crystal 803RR	---	4.60	---	4.45	4.45	4.16	--	4.45	3.86	--	2
	566	Crystal 804RR	---	4.44	---	4.30	4.30	3.94	--	4.30	3.58	--	2
	514	Crystal 808RR	---	3.69	---	3.57	3.57	3.58	--	3.57	3.60	--	2
	571	Crystal 912RR	---	4.04	---	3.91	3.91	--	--	3.91	--	--	1
	560	Crystal 913RR	---	3.70	---	3.58	3.58	--	--	3.58	--	--	1
	509	Crystal 914RR	---	5.35	---	5.18	5.18	---	--	5.18	--	--	1
	564	Crystal 915RR	---	4.44	---	4.30	4.30	--	--	4.30	--	--	1
	553	Crystal 916RR	---	4.31	---	4.17	4.17	--	--	4.17	--	--	1
	550	Crystal 918RR	---	4.83	---	4.67	4.67	--	--	4.67	--	--	1
	575	Hilleshög HIL2230	---	5.11	---	4.95	4.95	4.45	--	4.95	3.96	--	2
	561	Hilleshög HIL2233	---	4.58	---	4.43	4.43	4.22	--	4.43	4.02	--	2
	537	Hilleshög HIL2315	---	4.84	---	4.68	4.68	--	--	4.68	--	--	1
	528	Hilleshög HIL2316	---	3.67	---	3.55	3.55	--	--	3.55	--	--	1
	525	Hilleshög HIL2317	---	4.09	---	3.96	3.96	--	--	3.96	--	--	1
	511	Hilleshög HIL2318	---	5.02	---	4.86	4.86	--	--	4.86	--	--	1
	576	Hilleshög HIL2319	---	5.39	---	5.22	5.22	--	--	5.22	--	--	1
	512	Hilleshög HIL2320	---	4.73	---	4.58	4.58	--	--	4.58	--	--	1
	562	Hilleshög HM4302RR	---	5.37	---	5.20	5.20	4.93	5.50	5.20	4.65	6.66	9
	522	Hilleshög HM4448RR	---	5.02	---	4.86	4.86	4.70	5.23	4.86	4.53	6.29	7
	552	Hilleshög HM9528RR	---	4.71	---	4.56	4.56	4.39	4.80	4.56	4.22	5.63	6
	506	Hilleshög HIL9708	---	4.76	---	4.61	4.61	4.43	4.93	4.61	4.25	5.94	5
	536	Hilleshög HIL9920	---	5.22	---	5.05	5.05	4.57	4.70	5.05	4.09	4.94	3
	521	Maribo MA109	---	5.46	---	5.28	5.28	4.83	4.91	5.28	4.38	5.06	6
	517	Maribo MA504	---	6.37	---	6.17	6.17	5.73	5.89	6.17	5.30	6.20	5
	507	Maribo MA717	---	4.57	---	4.42	4.42	4.29	4.63	4.42	4.15	5.31	3
	579	Maribo MA901	---	5.06	---	4.90	4.90	--	--	4.90	--	--	1
	508	Maribo MA902	---	5.49	---	5.31	5.31	--	--	5.31	--	--	1
	542	Maribo MA903	---	4.71	---	4.56	4.56	--	--	4.56	--	--	1
	530	SX 1887	---	4.83	---	4.67	4.67	4.58	--	4.67	4.49	--	2
	547	SX 1888	---	4.80	---	4.65	4.65	4.34	--	4.65	4.03	--	2

Table 25 cont

	503	SX 1894	---	4.95		---	4.79	4.79	--	--	4.79	--	--	1
	556	SX 1895	---	4.49		---	4.35	4.35	--	--	4.35	--	--	1
	534	SX 1896	---	5.63		---	5.45	5.45	--	--	5.45	--	--	1
	577	SX 1897	---	5.85		---	5.66	5.66	--	--	5.66	--	--	1
	559	SX 1898	---	4.90		---	4.74	4.74	--	--	4.74	--	--	1
	502	SX Bronco RR	---	5.56		---	5.38	5.38	4.71	4.77	5.38	4.05	4.88	4
	558	SX Canyon RR	---	5.16		---	4.99	4.99	4.67	4.55	4.99	4.34	4.33	6
	554	SX Marathon RR	---	5.32		---	5.15	5.15	4.94	4.80	5.15	4.72	4.52	5
	578	SV 285	---	4.62		---	4.47	4.47	4.23	--	4.47	3.98	--	2
	572	SV 289	---	5.48		---	5.30	5.30	4.86	--	5.30	4.42	--	2
	563	SV 391	---	5.09		---	4.93	4.93	--	--	4.93	--	--	1
	543	SV 392	---	5.43		---	5.26	5.26	--	--	5.26	--	--	1
	526	SV 393	---	5.20		---	5.03	5.03	--	--	5.03	--	--	1
	516	SV 394	---	5.52		---	5.34	5.34	--	--	5.34	--	--	1
	546	SV RR265	---	5.65		---	5.47	5.47	4.81	4.99	5.47	4.16	5.35	4
	567	SV RR268	---	5.25		---	5.08	5.08	4.65	4.67	5.08	4.21	4.71	4
	570	SV RR333	---	4.86		---	4.70	4.70	4.38	4.58	4.70	4.06	4.99	7
	541	SV RR351	---	5.84		---	5.65	5.65	5.07	4.77	5.65	4.50	4.18	5
	538	SV RR371	---	5.16		---	4.99	4.99	4.75	4.69	4.99	4.51	4.55	3
	519	SV RR375	---	5.20		---	5.03	5.03	4.43	4.47	5.03	3.83	4.54	3
1	1001	AP CK-32 CRYS981RR	---	2.97		---	2.87	2.87	3.33	3.28	2.87	3.79	3.19	11
1	1002	AP CK-33 CRYS768RR	---	5.01		---	4.85	4.85	4.71	4.72	4.85	4.56	4.74	13
1	1003	AP CK-35 BETA87RR58	---	5.57		---	5.39	5.39	5.53	5.31	5.39	5.68	4.86	13
1	1004	AP CK-41 CRYS765RR	---	6.16		---	5.96	5.96	5.98	5.99	5.96	5.99	6.01	9
1	1005	AP CK-43 BTS80RR32	---	4.65		---	4.50	4.50	4.55	4.58	4.50	4.60	4.64	10
1	1006	AP CK-44 SX VISION RR	---	5.23		---	5.06	5.06	5.04	5.09	5.06	5.03	5.17	11
1	1007	AP CK-45 CRYS986RR	---	4.75		---	4.60	4.60	4.30	4.27	4.60	4.01	4.22	11
1	1008	AP CK-47 CRYS101RR	---	3.02		---	2.92	2.92	3.35	3.51	2.92	3.79	3.83	9
1	1009	AP CK-49 BTS82RR33	---	5.43		---	5.26	5.26	5.29	5.62	5.26	5.32	6.29	8
1	1010	AP CK-51 CRYS246RR	---	5.10		---	4.94	4.94	5.08	4.94	4.94	5.22	4.65	8
1	1011	AP CK-52 HILL4094RR	---	5.93		---	5.74	5.74	5.16	4.96	5.74	4.57	4.58	12
1	1012	AP CK-55 CRYS247RR	---	5.06		---	4.90	4.90	5.11	4.74	4.90	5.33	4.00	8
1	1013	AP CK-56 BTS8363	---	5.42		---	5.25	5.25	5.20	5.00	5.25	5.15	4.60	7
1	1014	AP CK-57 CRYS578RR	---	4.73		---	4.58	4.58	4.54	4.55	4.58	4.50	4.56	5
1	1015	AP CK-58 CRYS572RR	---	5.30		---	5.13	5.13	4.80	4.76	5.13	4.47	4.69	5
	1016	AP CHK MOD RES RR	---	5.57		---	5.39	5.39	5.12	4.96	5.39	4.84	4.65	13
	1017	AP CHK RES RR	---	6.05		---	5.86	5.86	5.17	4.94	5.86	4.49	4.49	14
	1018	AP CHK SUS HYB#3	---	6.07		---	5.88	5.88	5.85	5.57	5.88	5.83	4.99	13
	1019	AP CHK SUS HYB#4	---	6.26		---	6.06	6.06	6.04	6.02	6.06	6.02	5.99	13
	1020	AP SUS RR#5	---	5.62		---	5.44	5.44	5.38	5.68	5.44	5.32	6.29	3
		Conventional												
	902	Crystal 620	---	4.86		---	4.70	4.70	4.25	4.19	4.70	3.79	4.09	4
	907	Crystal 840	---	4.17		---	4.03	4.03	3.92	--	4.03	3.80	--	2
	904	Crystal 950	---	5.00		---	4.84	4.84	--	--	4.84	--	--	1
	906	Crystal R761	---	4.58		---	4.43	4.43	4.26	4.18	4.43	4.09	4.01	13
	903	Hilleshög HM3035Rz	---	5.30		---	5.13	5.13	5.15	5.16	5.13	5.18	5.18	15
	905	Seedex 8869 Cnv	---	5.00		---	4.84	4.84	4.83	4.88	4.84	4.82	4.99	4
	901	SV 48777	---	5.05		---	4.89	4.89	5.01	4.74	4.89	5.13	4.20	3
	1012	AP CK-55 CRYS247RR	---	4.97		---	4.81	4.81	5.11	4.74	4.90	5.33	4.00	8
	1014	AP CK-57 CRYS578RR	---	4.89		---	4.73	4.73	4.54	4.55	4.58	4.50	4.56	5
	1015	AP CK-58 CRYS572RR	---	5.23		---	5.06	5.06	4.80	4.76	5.13	4.47	4.69	5
		Check Mean	---	4.96		---	4.80	4.80						
15		Trial Mean	---	4.92		---	4.76	4.76						
		Coeff. of Var. (%)	---	12.80		---	12.80							
		Mean LSD (0.05)	---	0.79		---	0.76							
		Mean LSD (0.01)	---	1.04		---	1.01							
		Sig Lvl	---	**		---	**							
		Adjustment Factor	---	0.97		---								
		^^ 2019 Root Rating was taken in early fall (1=healthy, 9+=severe damage).												
		++ Ratings adjusted to 2003 basis. (2000-2002 Aph nurseries). Ratings adjusted on the basis of checks.												

Table 26.

2019 Cercospora Ratings for Official Trial Entries

Betaseed (Randolph MN), BSDF (Frankenmuth MI) & NDSU (Foxhome MN)

			Unadjusted			Adjusted to 1982 Basis ++								
			Randolph	BSDF	Foxhome	Randolph	BSDF	Foxhome						Trial
Chk	Code	Description	Avg	Avg	Avg	Avg	Avg	Avg	2019	2 Yr	3 Yr	2018	2017	Yrs $$
			6 Dates+	5 Dates+	9 Dates+	6 Dates+	5 Dates+	9 Dates+	3 loc					
	573	BTS 8337	3.77	3.37	3.23	4.18	4.10	4.92	4.40	4.52	4.47	4.64	4.36	7
	540	BTS 8500	3.94	2.82	2.76	4.37	3.43	4.21	4.00	4.20	4.23	4.40	4.29	5
	515	BTS 8524	4.24	3.39	3.11	4.71	4.13	4.74	4.52	4.51	4.47	4.50	4.38	5
	574	BTS 8606	4.35	3.60	3.18	4.83	4.38	4.85	4.69	4.74	4.74	4.80	4.73	4
	504	BTS 8629	4.25	3.64	3.17	4.72	4.43	4.83	4.66	4.59	4.49	4.52	4.29	4
	518	BTS 8735	3.69	3.43	2.74	4.10	4.17	4.18	4.15	4.18	4.19	4.21	4.22	3
	513	BTS 8749	3.43	3.09	2.80	3.81	3.76	4.27	3.95	4.02	4.03	4.10	4.05	3
	510	BTS 8767	3.93	3.21	2.95	4.36	3.91	4.50	4.26	4.29	4.24	4.32	4.16	3
	524	BTS 8784	3.37	3.09	2.63	3.74	3.76	4.01	3.84	3.78	3.74	3.73	3.65	3
	580	BTS 8815	4.28	3.48	3.18	4.75	4.24	4.85	4.61	4.63	--	4.65	--	2
	557	BTS 8882	4.09	3.19	2.70	4.54	3.88	4.12	4.18	4.35	--	4.53	--	2
	539	BTS 8927	4.26	3.26	2.86	4.73	3.97	4.36	4.35	--	--	--	--	1
	505	BTS 8938	3.83	3.67	2.85	4.25	4.47	4.34	4.35	--	--	--	--	1
	531	BTS 8945	3.92	3.42	3.09	4.35	4.16	4.71	4.41	--	--	--	--	1
	555	BTS 8958	3.02	2.86	2.73	3.35	3.48	4.16	3.66	--	--	--	--	1
	568	BTS 8961	3.83	3.25	3.01	4.25	3.96	4.59	4.27	--	--	--	--	1
	545	BTS 8976	3.71	2.91	2.51	4.12	3.54	3.83	3.83	--	--	--	--	1
	565	BTS 8985	3.66	3.21	2.84	4.06	3.91	4.33	4.10	--	--	--	--	1
	535	BTS 8989	3.54	2.83	2.89	3.93	3.44	4.41	3.93	--	--	--	--	1
	527	BTS 8994	4.12	3.09	2.67	4.57	3.76	4.07	4.13	--	--	--	--	1
	520	BTS 8995	3.50	2.78	2.60	3.88	3.38	3.96	3.74	--	--	--	--	1
	551	Crystal 093RR	4.57	4.01	3.48	5.07	4.88	5.31	5.09	4.98	4.82	4.88	4.49	10
	544	Crystal 247RR	4.16	3.61	2.94	4.62	4.39	4.48	4.50	4.52	4.53	4.54	4.55	8
	569	Crystal 355RR	3.96	3.57	3.47	4.40	4.34	5.29	4.68	4.60	4.52	4.52	4.36	7
	549	Crystal 572RR	3.95	3.82	3.29	4.38	4.65	5.02	4.68	4.56	4.47	4.45	4.27	5
	529	Crystal 574RR	4.00	3.17	2.97	4.44	3.86	4.53	4.28	4.35	4.35	4.42	4.35	5
	532	Crystal 578RR	4.13	3.95	2.97	4.58	4.81	4.53	4.64	4.69	4.76	4.74	4.91	5
	523	Crystal 684RR	4.02	2.89	2.88	4.46	3.52	4.39	4.12	4.27	4.29	4.41	4.34	4
	548	Crystal 793RR	3.59	3.12	2.84	3.98	3.80	4.33	4.04	4.15	4.08	4.26	3.93	3
	501	Crystal 796RR	4.23	3.87	3.16	4.70	4.71	4.82	4.74	4.74	4.78	4.74	4.85	3
	533	Crystal 803RR	3.41	3.08	2.70	3.78	3.75	4.12	3.88	3.95	--	4.01	--	2
	566	Crystal 804RR	4.27	3.42	2.93	4.74	4.16	4.47	4.46	4.44	--	4.42	--	2
	514	Crystal 808RR	4.50	3.50	3.33	4.99	4.26	5.08	4.78	4.82	--	4.86	--	2
	571	Crystal 912RR	4.34	3.47	3.17	4.82	4.22	4.83	4.62	--	--	--	--	1
	560	Crystal 913RR	3.95	3.06	2.77	4.38	3.72	4.22	4.11	--	--	--	--	1
	509	Crystal 914RR	4.63	3.35	2.85	5.14	4.08	4.34	4.52	--	--	--	--	1
	564	Crystal 915RR	3.86	3.47	3.09	4.28	4.22	4.71	4.41	--	--	--	--	1
	553	Crystal 916RR	3.71	3.51	2.88	4.12	4.27	4.39	4.26	--	--	--	--	1
	550	Crystal 918RR	3.94	3.03	2.85	4.37	3.69	4.34	4.14	--	--	--	--	1
	575	Hilleshög HIL2230	4.62	4.12	3.00	5.13	5.01	4.57	4.91	4.81	--	4.71	--	2
	561	Hilleshög HIL2233	4.91	4.26	3.37	5.45	5.18	5.14	5.26	5.06	--	4.87	--	2
	537	Hilleshög HIL2315	4.42	4.22	2.98	4.91	5.14	4.54	4.86	--	--	--	--	1
	528	Hilleshög HIL2316	4.22	3.97	2.90	4.68	4.83	4.42	4.65	--	--	--	--	1
	525	Hilleshög HIL2317	4.66	3.67	3.31	5.17	4.47	5.05	4.90	--	--	--	--	1
	511	Hilleshög HIL2318	4.29	3.53	2.59	4.76	4.30	3.95	4.34	--	--	--	--	1
	576	Hilleshög HIL2319	4.95	4.69	3.37	5.49	5.71	5.14	5.45	--	--	--	--	1
	512	Hilleshög HIL2320	4.52	3.82	3.35	5.02	4.65	5.11	4.92	--	--	--	--	1
	506	Hilleshög HIL9708	4.68	4.18	3.01	5.19	5.09	4.59	4.96	4.83	4.76	4.71	4.61	5
	536	Hilleshög HIL9920	4.06	4.23	3.41	4.51	5.15	5.20	4.95	4.87	4.88	4.79	4.89	3
	562	Hilleshög HM4302RR	3.65	3.16	2.55	4.05	3.85	3.89	3.93	4.09	4.04	4.26	3.93	9
	522	Hilleshög HM4448RR	5.03	4.72	3.35	5.58	5.74	5.11	5.48	5.37	5.34	5.26	5.28	7
	552	Hilleshög HM9528RR	4.68	3.99	3.11	5.19	4.86	4.74	4.93	4.86	4.90	4.79	4.99	6
	521	Maribo MA109	3.56	3.43	2.68	3.95	4.17	4.09	4.07	4.20	4.18	4.33	4.14	6
	517	Maribo MA504	5.07	4.42	3.28	5.63	5.38	5.00	5.34	5.16	5.27	4.98	5.50	5
	507	Maribo MA717	4.62	4.36	3.22	5.13	5.31	4.91	5.11	4.95	4.91	4.78	4.85	3
	579	Maribo MA901	4.39	3.71	2.83	4.87	4.52	4.31	4.57	--	--	--	--	1
	508	Maribo MA902	4.64	4.03	3.07	5.15	4.90	4.68	4.91	--	--	--	--	1
	542	Maribo MA903	4.99	4.10	3.42	5.54	4.99	5.21	5.25	--	--	--	--	1
	578	SV 285	4.32	3.64	3.47	4.79	4.43	5.29	4.84	4.68	--	4.52	--	2
	572	SV 289	3.89	4.09	2.93	4.32	4.98	4.47	4.59	4.62	--	4.65	--	2
	563	SV 391	4.63	4.04	3.39	5.14	4.92	5.17	5.07	--	--	--	--	1
	543	SV 392	5.26	4.31	3.30	5.84	5.25	5.03	5.37	--	--	--	--	1
	526	SV 393	4.45	4.13	3.19	4.94	5.03	4.86	4.94	--	--	--	--	1
	516	SV 394	4.37	3.94	2.94	4.85	4.80	4.48	4.71	--	--	--	--	1
	546	SV RR265	3.78	3.60	2.80	4.20	4.38	4.27	4.28	4.38	4.65	4.48	5.19	4
	567	SV RR268	4.27	4.12	3.09	4.74	5.01	4.71	4.82	4.76	4.86	4.70	5.06	4
	570	SV RR333	3.77	3.59	3.22	4.18	4.37	4.91	4.49	4.64	4.70	4.78	4.84	7
	541	SV RR351	4.31	4.08	3.25	4.78	4.97	4.95	4.90	4.76	4.64	4.61	4.41	5

Table 26 cont

	538	SV RR371	3.90	3.45	2.94	4.33	4.20	4.48	4.34	4.52	4.55	4.71	4.59	3
	519	SV RR375	3.50	3.59	2.67	3.88	4.37	4.07	4.11	4.54	4.72	4.96	5.08	3
	530	SX 1887	4.31	3.88	3.38	4.78	4.72	5.15	4.89	4.89	--	4.89	--	2
	547	SX 1888	4.44	3.82	3.34	4.93	4.65	5.09	4.89	4.90	--	4.92	--	2
	503	SX 1894	4.96	4.03	3.26	5.51	4.90	4.97	5.13	--	--	--	--	1
	556	SX 1895	3.95	3.73	3.11	4.38	4.54	4.74	4.56	--	--	--	--	1
	534	SX 1896	4.68	3.96	3.13	5.19	4.82	4.77	4.93	--	--	--	--	1
	577	SX 1897	4.70	3.66	3.12	5.22	4.45	4.76	4.81	--	--	--	--	1
	559	SX 1898	4.31	3.89	2.96	4.78	4.73	4.51	4.68	--	--	--	--	1
	502	SX Bronco RR	4.17	4.15	3.04	4.63	5.05	4.63	4.77	4.71	4.50	4.65	4.08	4
	558	SX Canyon RR	3.97	3.97	2.96	4.41	4.83	4.51	4.58	4.69	4.76	4.79	4.92	6
	554	SX Marathon RR	4.33	3.74	3.29	4.81	4.55	5.02	4.79	5.03	4.87	5.27	4.54	5
1	1101	CR CK#19 CRYS539RR	5.05	3.98	3.47	5.61	4.84	5.29	5.25	5.32	5.38	5.39	5.49	15
1	1102	CR CK#24 HILL4012RR	4.65	4.60	3.43	5.16	5.60	5.23	5.33	5.45	5.34	5.56	5.13	14
1	1103	CR CK#28 HILL4010RR	4.80	4.02	3.21	5.33	4.89	4.89	5.04	5.15	5.25	5.27	5.44	14
1	1104	CR CK#41 CRYS981RR	4.66	4.03	3.39	5.17	4.90	5.17	5.08	5.04	4.99	5.00	4.90	11
1	1105	CR CK#43 CRYS246RR	4.40	3.67	3.09	4.88	4.47	4.71	4.69	4.73	4.75	4.78	4.77	8
1	1106	CR CK#44 BETA80RR32	4.44	3.99	3.40	4.93	4.86	5.18	4.99	5.03	5.00	5.06	4.94	10
1	1107	CR CK#45 HILL4448RR	5.05	5.06	3.35	5.61	6.16	5.11	5.62	5.38	5.33	5.14	5.24	8
1	1108	CR CK#47 HILL4094RR	3.66	3.62	2.87	4.06	4.41	4.38	4.28	4.37	4.35	4.46	4.31	12
1	1109	CR CK#48 MARI504	4.95	4.39	3.48	5.49	5.34	5.31	5.38	5.19	5.29	4.99	5.50	5
1	1110	CR CK#49 CRYS578RR	4.10	3.91	3.21	4.55	4.76	4.89	4.73	4.77	4.82	4.80	4.91	5
1	1111	CR CK#50 CRYS101RR	3.90	4.01	3.03	4.33	4.88	4.62	4.61	4.57	4.57	4.53	4.57	9
1	1112	CR CK#51 CRYS355RR	3.96	3.62	3.11	4.40	4.41	4.74	4.51	4.52	4.47	4.53	4.36	7
	1113	CR CK MOD SUS HYB#3	5.09	4.12	3.42	5.65	5.01	5.21	5.29	5.37	5.38	5.44	5.41	15
	1114	CR CK MOD RES HYB#4	3.58	3.32	3.12	3.97	4.04	4.76	4.26	4.31	4.28	4.35	4.22	12
	1115	CR CK MOD RES HYB#4	3.60	3.63	3.06	4.00	4.42	4.66	4.36	4.36	4.31	4.35	4.22	12
	1116	CR CK MOD SUS HYB#5	4.93	4.21	3.61	5.47	5.12	5.50	5.37	5.33	5.26	5.29	5.11	13
		Conventional												
	902	Crystal 620	3.66	3.37	2.43	4.06	4.10	3.70	3.95	4.13	4.13	4.30	4.14	4
	907	Crystal 840	4.03	3.55	2.46	4.47	4.32	3.76	4.18	4.25	--	4.33	--	2
	904	Crystal 950	4.37	3.89	3.01	4.85	4.73	4.59	4.72	--	--	--	--	1
	906	Crystal R761	4.37	4.40	3.11	4.85	5.36	4.75	4.98	4.85	4.88	4.72	4.93	13
	903	Hilleshög HM3035Rz	3.90	3.98	2.68	4.33	4.84	4.09	4.42	4.32	4.36	4.23	4.42	15
	905	Seedex 8869 Cnv	4.05	4.03	2.73	4.50	4.90	4.16	4.52	4.59	4.80	4.66	5.21	4
	901	SV 48777	3.48	3.55	2.69	3.87	4.32	4.11	4.10	4.33	4.47	4.56	4.76	3
	1107	CR CK#45 HILL4448RR	5.00	4.97	3.33	5.55	6.05	5.08	5.56	5.35	5.31	5.14	5.24	8
	1109	CR CK#48 MARI504	4.73	4.50	3.33	5.25	5.48	5.08	5.27	5.13	5.25	4.99	5.50	5
	1110	CR CK#49 CRYS578RR	4.37	3.89	3.37	4.85	4.73	5.14	4.91	4.85	4.87	4.80	4.91	5
12		Check Mean	4.47	4.08	3.25	4.96	4.96	4.96	4.96					
		Trial Mean	4.20	3.71	3.07	4.66	4.52	4.68	4.62					
		Coeff. of Var. (%)	5.64	6.84	7.25	5.64	6.84	7.25						
		Mean LSD (0.05)	0.30	0.44	0.28	0.33	0.54	0.43						
		Mean LSD (0.01)	0.40	0.58	0.36	0.44	0.71	0.55						
		Sig Mrk	**	**	**	**	**	**						
		Adj Factor				1.10995	1.21708	1.52447						

* Lower numbers indicate better Cercospora resistance (1-Ex,9=Poor).

++ Ratings adjusted to 1982 basis (5.5 equivalent in 1978-81 CR nurseries). Ratings adjusted on the basis of checks.

Chk = varieties used to adjust CR readings to 1982 basis. Ratings * (Adj. factor) = Adj Rating.

$$ Trial years indicates how many years the entry has been in the official trials.

Created 11-19-2019

Table 27

2019 Rhizoctonia Ratings for OVT Entries

Rhizoctonia Nursery - BSDF, NWROC & One ACSC Site

Sus Chk ^	Chk @	Code	Description	Unadjusted BSDF 8/21	Unadjusted TSC-E 7/31	Unadjusted TSC-W	Unadjusted NWROC 7/23	Adjusted @ BSDF 8/21	Adjusted @ TSC-E 7/16	Adjusted @ TSC-W	Adjusted @ NWROC 7/23	2019	2 Yr	3 Yr	2018	2017	Years
		573	BTS 8337	4.10	3.64	---	2.94	3.78	3.55	---	3.51	3.62	3.84	3.99	4.07	4.30	7
		540	BTS 8500	4.45	4.29	---	3.81	4.11	4.19	---	4.55	4.28	4.32	4.40	4.36	4.57	5
		515	BTS 8524	4.60	4.28	---	3.00	4.25	4.18	---	3.58	4.00	4.12	4.21	4.23	4.41	5
		574	BTS 8606	4.82	4.95	---	3.78	4.45	4.83	---	4.51	4.60	4.42	4.61	4.24	5.00	4
		504	BTS 8629	4.32	3.96	---	3.21	3.99	3.87	---	3.83	3.89	3.96	4.04	4.02	4.21	4
		518	BTS 8735	4.16	3.94	---	3.50	3.84	3.85	---	4.18	3.95	4.04	4.15	4.12	4.38	3
		513	BTS 8749	4.29	3.28	---	3.01	3.96	3.20	---	3.59	3.58	3.73	3.81	3.88	3.95	3
		510	BTS 8767	4.63	4.40	---	3.22	4.27	4.30	---	3.84	4.14	4.12	4.33	4.10	4.75	3
		524	BTS 8784	4.68	4.11	---	3.80	4.32	4.01	---	4.54	4.29	4.44	4.51	4.60	4.64	3
		580	BTS 8815	4.61	4.10	---	3.21	4.25	4.00	---	3.83	4.03	3.95	--	3.88	--	2
		557	BTS 8882	4.45	4.48	---	3.62	4.11	4.37	---	4.32	4.27	4.32	--	4.37	--	2
		539	BTS 8927	4.49	4.15	---	3.00	4.14	4.05	---	3.58	3.93	--	--	--	--	1
		505	BTS 8938	3.72	3.43	---	3.05	3.43	3.35	---	3.64	3.47	--	--	--	--	1
		531	BTS 8945	3.83	3.59	---	3.57	3.53	3.50	---	4.26	3.77	--	--	--	--	1
		555	BTS 8958	4.60	3.88	---	2.90	4.25	3.79	---	3.46	3.83	--	--	--	--	1
		568	BTS 8961	4.31	3.78	---	3.09	3.98	3.69	---	3.69	3.79	--	--	--	--	1
		545	BTS 8976	4.02	4.22	---	3.55	3.71	4.12	---	4.24	4.02	--	--	--	--	1
		565	BTS 8985	4.23	4.43	---	3.16	3.90	4.32	---	3.77	4.00	--	--	--	--	1
		535	BTS 8989	5.25	5.10	---	3.84	4.85	4.98	---	4.58	4.80	--	--	--	--	1
		527	BTS 8994	4.27	3.61	---	3.32	3.94	3.52	---	3.96	3.81	--	--	--	--	1
		520	BTS 8995	3.92	4.39	---	2.89	3.62	4.29	---	3.45	3.78	--	--	--	--	1
		551	Crystal 093RR	4.66	4.04	---	3.50	4.30	3.94	---	4.18	4.14	4.37	4.41	4.59	4.50	10
		544	Crystal 247RR	5.02	4.13	---	3.59	4.63	4.03	---	4.28	4.32	4.44	4.45	4.56	4.49	8
		569	Crystal 355RR	4.06	3.85	---	2.94	3.75	3.76	---	3.51	3.67	3.66	3.81	3.66	4.09	7
		549	Crystal 572RR	4.63	4.10	---	3.46	4.27	4.00	---	4.13	4.14	4.34	4.38	4.54	4.47	5
		529	Crystal 574RR	4.97	4.48	---	3.68	4.59	4.37	---	4.39	4.45	4.41	4.32	4.36	4.16	5
		532	Crystal 578RR	4.73	4.17	---	3.52	4.37	4.07	---	4.20	4.21	4.25	4.30	4.30	4.40	5
		523	Crystal 684RR	4.48	4.19	---	3.18	4.13	4.09	---	3.80	4.01	4.20	4.32	4.39	4.57	4
		548	Crystal 793RR	4.50	4.19	---	3.60	4.15	4.09	---	4.30	4.18	4.15	4.18	4.11	4.26	3
		501	Crystal 796RR	4.43	3.97	---	3.01	4.09	3.88	---	3.59	3.85	3.91	4.02	3.97	4.23	3
		533	Crystal 803RR	4.52	4.61	---	4.14	4.17	4.50	---	4.94	4.54	4.60	--	4.67	--	2
		566	Crystal 804RR	4.34	3.60	---	3.06	4.01	3.51	---	3.65	3.72	3.87	--	4.02	--	2
		514	Crystal 808RR	4.71	4.18	---	3.22	4.35	4.08	---	3.84	4.09	3.96	--	3.83	--	2
		571	Crystal 912RR	3.71	3.69	---	3.10	3.42	3.60	---	3.70	3.58	--	--	--	--	1
		560	Crystal 913RR	4.77	4.17	---	3.73	4.40	4.07	---	4.45	4.31	--	--	--	--	1
		509	Crystal 914RR	4.63	4.62	---	3.26	4.27	4.51	---	3.89	4.22	--	--	--	--	1
		564	Crystal 915RR	4.40	4.48	---	3.26	4.06	4.37	---	3.89	4.11	--	--	--	--	1
		553	Crystal 916RR	4.97	4.10	---	3.50	4.59	4.00	---	4.18	4.26	--	--	--	--	1
		550	Crystal 918RR	4.82	3.68	---	3.22	4.45	3.59	---	3.84	3.96	--	--	--	--	1
		575	Hilleshög HIL2230	5.15	4.28	---	3.77	4.75	4.18	---	4.50	4.48	4.27	--	4.06	--	2
		561	Hilleshög HIL2233	4.03	3.88	---	3.22	3.72	3.79	---	3.84	3.78	3.91	--	4.04	--	2
		537	Hilleshög HIL2315	4.11	4.28	---	3.74	3.79	4.18	---	4.46	4.15	--	--	--	--	1
		528	Hilleshög HIL2316	4.49	4.44	---	3.73	4.14	4.33	---	4.45	4.31	--	--	--	--	1
		525	Hilleshög HIL2317	3.96	4.17	---	4.07	3.65	4.07	---	4.86	4.19	--	--	--	--	1
		511	Hilleshög HIL2318	4.37	4.49	---	3.18	4.03	4.38	---	3.80	4.07	--	--	--	--	1
		576	Hilleshög HIL2319	4.64	4.03	---	3.12	4.28	3.93	---	3.72	3.98	--	--	--	--	1
		512	Hilleshög HIL2320	4.75	3.91	---	3.29	4.38	3.82	---	3.93	4.04	--	--	--	--	1
		562	Hilleshög HM4302RR	4.53	4.80	---	2.54	4.18	4.69	---	3.03	3.97	3.84	3.76	3.71	3.60	9
		522	Hilleshög HM4448RR	4.95	4.03	---	3.03	4.57	3.93	---	3.62	4.04	4.21	4.35	4.38	4.63	7
		552	Hilleshög HM9528RR	4.27	4.33	---	3.45	3.94	4.23	---	4.12	4.10	4.07	4.12	4.04	4.21	6
		506	Hilleshög HIL9708	4.43	3.93	---	3.08	4.09	3.84	---	3.68	3.87	3.79	3.93	3.71	4.21	5
		536	Hilleshög HIL9920	4.99	4.47	---	4.26	4.61	4.36	---	5.08	4.68	4.67	4.60	4.65	4.48	3
		521	Maribo MA109	3.82	3.88	---	3.26	3.53	3.79	---	3.89	3.73	3.71	3.69	3.69	3.63	6
		517	Maribo MA504	5.23	5.15	---	3.52	4.83	5.03	---	4.20	4.69	4.47	4.43	4.25	4.37	5
		507	Maribo MA717	4.58	4.32	---	3.36	4.23	4.22	---	4.01	4.15	4.25	4.26	4.35	4.28	3
		579	Maribo MA901	4.66	4.15	---	3.36	4.30	4.05	---	4.01	4.12	--	--	--	--	1
		508	Maribo MA902	4.55	4.26	---	2.98	4.20	4.16	---	3.56	3.97	--	--	--	--	1
		542	Maribo MA903	4.11	3.96	---	3.36	3.79	3.87	---	4.01	3.89	--	--	--	--	1
		530	SX 1887	4.58	4.21	---	3.51	4.23	4.11	---	4.19	4.18	4.17	--	4.16	--	2
		547	SX 1888	4.93	4.52	---	3.02	4.55	4.41	---	3.60	4.19	4.38	--	4.57	--	2
		503	SX 1894	4.42	4.45	---	3.68	4.08	4.34	---	4.39	4.27	--	--	--	--	1
		556	SX 1895	4.52	4.79	---	3.52	4.17	4.68	---	4.20	4.35	--	--	--	--	1
		534	SX 1896	4.56	4.58	---	4.00	4.21	4.47	---	4.77	4.48	--	--	--	--	1
		577	SX 1897	4.71	4.11	---	3.23	4.35	4.01	---	3.85	4.07	--	--	--	--	1
		559	SX 1898	4.47	4.70	---	3.29	4.13	4.59	---	3.93	4.21	--	--	--	--	1
		502	SX Bronco RR	4.59	5.02	---	4.18	4.24	4.90	---	4.99	4.71	4.72	4.56	4.73	4.23	4
		558	SX Canyon RR	4.78	3.70	---	3.05	4.41	3.61	---	3.64	3.89	4.12	4.25	4.36	4.51	6
		554	SX Marathon RR	4.91	4.59	---	3.42	4.53	4.48	---	4.08	4.36	4.28	4.32	4.19	4.40	5
		578	SV 285	5.12	4.45	---	3.42	4.73	4.34	---	4.08	4.38	4.37	--	4.35	--	2
		572	SV 289	4.68	4.05	---	3.28	4.32	3.95	---	3.91	4.06	4.22	--	4.37	--	2
		563	SV 391	4.30	4.48	---	3.32	3.97	4.37	---	3.96	4.10	--	--	--	--	1
		543	SV 392	4.20	4.40	---	3.34	3.88	4.30	---	3.99	4.05	--	--	--	--	1
		526	SV 393	4.67	4.61	---	3.50	4.31	4.50	---	4.18	4.33	--	--	--	--	1
		516	SV 394	4.54	5.12	---	3.52	4.19	5.00	---	4.20	4.46	--	--	--	--	1
		546	SV RR265	4.93	4.74	---	3.00	4.55	4.63	---	3.58	4.25	4.29	4.33	4.32	4.42	4
		567	SV RR268	4.92	4.30	---	3.25	4.54	4.20	---	3.88	4.21	4.21	4.33	4.21	4.57	4
		570	SV RR333	4.39	4.13	---	3.48	4.05	4.03	---	4.15	4.08	4.16	4.25	4.23	4.44	7
		541	SV RR351	4.37	4.07	---	3.56	4.03	3.97	---	4.25	4.09	4.12	4.16	4.16	4.25	5
		538	SV RR371	4.42	4.05	---	3.26	4.08	3.95	---	3.89	3.97	4.08	4.16	4.19	4.31	3
		519	SV RR375	4.53	4.10	---	3.32	4.18	4.00	---	3.96	4.05	4.09	4.14	4.13	4.25	3

Table 27 cont

1	1	1301	RH CK#08 CRYS539RR	4.81	4.73	---	4.15	4.44	4.62	---	4.95	4.67	4.67	4.70	4.68	4.74	11
1	1	1302	RH CK#21 CRYS768RR	5.49	4.29	---	3.97	5.07	4.19	---	4.74	4.66	4.59	4.61	4.52	4.66	11
1	1	1303	RH CK#25 HILL4043RR	4.76	4.73	---	4.17	4.39	4.62	---	4.98	4.66	4.75	4.67	4.83	4.51	11
	1	1304	RH CK#28 CRYS658RR	4.56	4.88	---	3.47	4.21	4.76	---	4.14	4.37	4.19	4.25	4.02	4.36	14
	1	1305	RH CK#35 SES36812RR	5.11	4.33	---	3.29	4.72	4.23	---	3.93	4.29	4.29	4.43	4.29	4.71	12
	1	1306	RH CK#36 BTS85RR02	4.53	4.85	---	3.99	4.18	4.74	---	4.76	4.56	4.51	4.37	4.46	4.10	15
	1	1307	RH CK#37 SES36918RR	5.28	4.38	---	4.27	4.87	4.28	---	5.10	4.75	4.54	4.50	4.32	4.43	11
1	1	1308	RH CK#40 CRYS101RR	4.90	5.38	---	3.71	4.52	5.25	---	4.43	4.73	4.61	4.59	4.50	4.55	9
1	1	1309	RH CK#45 BTS82RR33	4.82	4.04	---	3.24	4.45	3.94	---	3.87	4.09	4.39	4.51	4.70	4.73	8
	1	1310	RH CK#47 SES36272RR	5.21	4.23	---	3.22	4.81	4.13	---	3.84	4.26	4.31	4.41	4.36	4.62	8
	1	1311	RH CK#48 HILL4094RR	4.32	4.16	---	3.26	3.99	4.06	---	3.89	3.98	3.85	3.83	3.72	3.80	12
1	1	1312	RH CK#49 CRYS247RR	4.36	3.95	---	3.85	4.02	3.86	---	4.59	4.16	4.39	4.47	4.62	4.65	8
1	1	1313	RH CK#51 SXWinchester	4.41	4.56	---	3.68	4.07	4.45	---	4.39	4.30	4.40	4.43	4.50	4.47	7
1	1	1314	RH CK#52 CRYS573RR	4.37	4.40	---	3.57	4.03	4.30	---	4.26	4.20	4.34	4.41	4.48	4.57	5
1	1	1315	RH CK#53 BTS8500	4.93	5.02	---	3.73	4.55	4.90	---	4.45	4.63	4.48	4.51	4.32	4.57	5
		1316	MOD RHC #6	4.81	4.63	---	4.74	4.44	4.52	---	5.66	4.87	4.49	4.55	4.11	4.68	13
		1317	RES RHC #1	4.24	4.30	---	3.41	3.91	4.20	---	4.07	4.06	3.77	3.72	3.49	3.62	14
		1318	RES RHC #3	4.52	4.11	---	2.94	4.17	4.01	---	3.51	3.90	3.63	3.63	3.36	3.63	6
		1319	SUS RHC #10	4.80	4.31	---	3.56	4.43	4.21	---	4.25	4.30	4.40	4.36	4.51	4.28	11
		1320	SUS RHC #3	4.86	4.64	---	3.97	4.49	4.53	---	4.74	4.58	4.65	4.64	4.71	4.64	15
			Conventional														
		902	Crystal 620	5.00	6.26	---	3.93	4.61	6.11	---	4.69	5.14	4.64	4.55	4.15	4.37	4
		907	Crystal 840	4.17	6.09	---	3.72	3.85	5.95	---	4.44	4.75	4.39	--	4.04	--	2
		904	Crystal 950	5.01	5.81	---	3.52	4.62	5.67	---	4.20	4.83	--	--	--	--	1
		906	Crystal R761	4.12	6.37	---	3.91	3.81	6.22	---	4.67	4.90	4.63	4.60	4.36	4.54	13
		903	Hilleshög HM3035Rz	3.94	5.72	---	3.25	3.64	5.59	---	3.88	4.37	4.19	4.15	4.01	4.07	15
		905	Seedex 8869 Cnv	5.57	5.83	---	3.87	5.14	5.69	---	4.61	5.15	4.86	4.70	4.56	4.40	4
		901	SV 48777	5.17	5.94	---	3.63	4.77	5.80	---	4.33	4.97	4.73	4.68	4.49	4.59	3
		1308	RH CK#40 CRYS101RR	4.72	5.07	---	3.67	4.36	4.95	---	4.38	4.56	4.53	4.54	4.50	4.55	9
		1314	RH CK#52 CRYS573RR	4.60	5.07	---	3.51	4.25	4.95	---	4.18	4.46	4.47	4.50	4.48	4.57	5
		1315	RH CK#53 BTS8500	4.88	4.66	---	3.83	4.50	4.55	---	4.57	4.54	4.43	4.48	4.32	4.57	5
	15		Mean of Check Varieties	4.791	4.529	---	3.705	4.421	4.421	---	4.421	4.421	4.421	4.447	4.421	4.498	
9			Mean of Susc Checks	4.761	4.567	---	3.786	4.394	4.458	---	4.518	4.457	4.514	4.545	4.571	4.606	
			Trial Mean	4.56	4.28	---	3.44	4.21	4.18	---	4.105						
			Coeff. of Var. (%)	14.17	14.99	---	13.04	14.17	14.99	---	13.0						
			Mean LSD (0.05)	0.86	0.79	---	0.58	0.79	0.77	---	0.69						
			Mean LSD (0.01)	1.13	1.04	---	0.76	1.04	1.02	---	0.91						
			Sig Lvl	**	**	---	**	**	**	---	**						
			Adjustment Factor	0.9229	0.9763	---	1.1934										
			Approval Limit (80% of susc (	3.81	3.65	---	3.03	3.52	3.57	---	3.61	3.57	3.61	3.64	3.66	3.68	
			++ Adjustment is based upon check varieties.														
			@ Ratings adjusted to 2009 basis (2007-2009) RH nurseries. Ratings adjusted on the basis of checks														
			Lower numbers indicate better tolerance (0=Ex, 7=Poor).														
			^ Approval criteria is based upon the mean of susc varieties (approval option 1) or 3.82 (approval option 2).														

Table 28.

2019 Fusarium Ratings for Official Trial Entries

ACSC Nurseries - (Two Moorhead, MN Sites)

Chk @	Code	Description	Unadjusted N Mhd 4 Dates+	Unadjusted S Mhd 4 Dates+	Adjusted N Mhd 4 Dates+	Adjusted S Mhd 4 Dates+	2019	2 Yr	3 Yr	2018	2017	Years
	573	BTS 8337	3.53	3.29	3.14	3.99	3.57	3.87	3.86	4.18	3.83	7
	540	BTS 8500	1.79	2.43	1.59	2.95	2.27	2.37	2.29	2.46	2.14	5
	515	BTS 8524	2.76	3.15	2.46	3.82	3.14	3.54	3.44	3.93	3.24	5
	574	BTS 8606	2.46	2.62	2.19	3.18	2.68	3.17	3.05	3.66	2.81	4
	504	BTS 8629	3.63	3.45	3.23	4.18	3.71	4.05	4.10	4.40	4.20	4
	518	BTS 8735	3.72	2.66	3.31	3.23	3.27	3.65	3.75	4.04	3.93	3
	513	BTS 8749	2.76	2.98	2.46	3.61	3.04	3.41	3.37	3.79	3.28	3
	510	BTS 8767	1.93	2.62	1.72	3.18	2.45	2.93	2.86	3.41	2.71	3
	524	BTS 8784	2.34	2.90	2.08	3.52	2.80	3.28	3.07	3.76	2.63	3
	580	BTS 8815	2.35	2.71	2.09	3.29	2.69	3.16	--	3.64	--	2
	557	BTS 8882	2.51	2.96	2.24	3.59	2.91	3.15	--	3.39	--	2
	539	BTS 8927	2.31	2.87	2.06	3.48	2.77	--	--	--	--	1
	505	BTS 8938	3.05	2.81	2.72	3.41	3.06	--	--	--	--	1
	531	BTS 8945	2.69	2.97	2.40	3.60	3.00	--	--	--	--	1
	555	BTS 8958	1.64	2.56	1.46	3.11	2.28	--	--	--	--	1
	568	BTS 8961	2.12	2.65	1.89	3.21	2.55	--	--	--	--	1
	545	BTS 8976	3.59	3.43	3.20	4.16	3.68	--	--	--	--	1
	565	BTS 8985	2.68	2.74	2.39	3.32	2.86	--	--	--	--	1
	535	BTS 8989	3.13	3.44	2.79	4.17	3.48	--	--	--	--	1
	527	BTS 8994	2.07	3.25	1.84	3.94	2.89	--	--	--	--	1
	520	BTS 8995	2.18	3.07	1.94	3.72	2.83	--	--	--	--	1
	551	Crystal 093RR	2.91	2.95	2.59	3.58	3.09	3.68	3.61	4.28	3.48	10
	544	Crystal 247RR	2.29	2.40	2.04	2.91	2.48	2.91	2.94	3.34	3.00	8
	569	Crystal 355RR	1.98	2.64	1.76	3.20	2.48	3.11	2.99	3.73	2.76	7
	549	Crystal 572RR	2.02	2.45	1.80	2.97	2.39	3.04	2.91	3.70	2.64	5
	529	Crystal 574RR	1.58	2.19	1.41	2.66	2.03	2.45	2.38	2.87	2.23	5
	532	Crystal 578RR	1.97	2.64	1.76	3.20	2.48	2.92	2.75	3.36	2.41	5
	523	Crystal 684RR	1.48	2.38	1.32	2.89	2.10	2.53	2.36	2.96	2.01	4
	548	Crystal 793RR	2.35	2.75	2.09	3.34	2.71	3.15	3.09	3.59	2.95	3
	501	Crystal 796RR	1.93	2.63	1.72	3.19	2.45	2.91	2.72	3.36	2.34	3
	533	Crystal 803RR	2.27	2.78	2.02	3.37	2.70	3.40	--	4.11	--	2
	566	Crystal 804RR	1.82	2.42	1.62	2.94	2.28	2.66	--	3.05	--	2
	514	Crystal 808RR	1.79	2.62	1.59	3.18	2.39	2.75	--	3.12	--	2
	571	Crystal 912RR	3.18	3.22	2.83	3.91	3.37	--	--	--	--	1
	560	Crystal 913RR	2.06	2.70	1.84	3.28	2.56	--	--	--	--	1
	509	Crystal 914RR	1.83	2.88	1.63	3.49	2.56	--	--	--	--	1
	564	Crystal 915RR	1.48	2.28	1.32	2.77	2.04	--	--	--	--	1
	553	Crystal 916RR	1.92	2.69	1.71	3.26	2.49	--	--	--	--	1
	550	Crystal 918RR	2.29	2.62	2.04	3.18	2.61	--	--	--	--	1
	575	Hilleshög HIL2230	4.75	3.66	4.23	4.44	4.34	4.60	--	4.86	--	2
	561	Hilleshög HIL2233	5.58	3.08	4.97	3.74	4.35	4.82	--	5.28	--	2
	537	Hilleshög HIL2315	4.25	3.65	3.79	4.43	4.11	--	--	--	--	1
	528	Hilleshög HIL2316	3.15	2.79	2.81	3.38	3.10	--	--	--	--	1
	525	Hilleshög HIL2317	6.18	4.20	5.51	5.09	5.30	--	--	--	--	1
	511	Hilleshög HIL2318	5.41	3.78	4.82	4.59	4.70	--	--	--	--	1
	576	Hilleshög HIL2319	4.87	3.67	4.34	4.45	4.40	--	--	--	--	1
	512	Hilleshög HIL2320	5.09	3.47	4.53	4.21	4.37	--	--	--	--	1
	562	Hilleshög HM4302RR	3.75	4.26	3.34	5.17	4.25	4.64	4.79	5.02	5.09	9
	522	Hilleshög HM4448RR	5.85	3.62	5.21	4.39	4.80	5.02	5.13	5.23	5.35	7
	552	Hilleshög HM9528RR	4.59	3.49	4.09	4.23	4.16	4.56	4.45	4.95	4.25	6
	506	Hilleshög HIL9708	4.03	3.45	3.59	4.18	3.89	4.25	4.37	4.61	4.61	5
	536	Hilleshög HIL9920	6.59	4.10	5.87	4.97	5.42	5.47	5.62	5.51	5.92	3
	521	Maribo MA109	3.92	3.78	3.49	4.59	4.04	4.49	4.41	4.95	4.23	6
	517	Maribo MA504	5.02	3.92	4.47	4.75	4.61	4.70	4.64	4.80	4.52	5
	507	Maribo MA717	5.54	3.87	4.94	4.69	4.81	4.84	4.88	4.86	4.95	3
	579	Maribo MA901	4.36	3.24	3.88	3.93	3.91	--	--	--	--	1
	508	Maribo MA902	3.76	3.36	3.35	4.08	3.71	--	--	--	--	1
	542	Maribo MA903	5.68	3.41	5.06	4.14	4.60	--	--	--	--	1
	530	SX 1887	5.36	3.78	4.78	4.59	4.68	5.01	--	5.35	--	2
	547	SX 1888	6.28	4.47	5.59	5.42	5.51	5.49	--	5.47	--	2

Table 28 cont

	503	SX 1894	4.40	3.41	3.92	4.14	4.03	--	--	--	--	1
	556	SX 1895	5.86	4.11	5.22	4.99	5.10	--	--	--	--	1
	534	SX 1896	4.42	3.60	3.94	4.37	4.15	--	--	--	--	1
	577	SX 1897	4.75	3.47	4.23	4.21	4.22	--	--	--	--	1
	559	SX 1898	6.34	3.82	5.65	4.63	5.14	--	--	--	--	1
	502	SX Bronco RR	6.61	4.11	5.89	4.99	5.44	5.48	5.67	5.52	6.04	4
	558	SX Canyon RR	5.15	3.98	4.59	4.83	4.71	4.82	4.92	4.93	5.12	6
	554	SX Marathon RR	6.51	4.62	5.80	5.60	5.70	5.61	5.35	5.51	4.84	5
	578	SV 285	5.21	4.02	4.64	4.88	4.76	5.09	--	5.42	--	2
	572	SV 289	6.96	4.42	6.20	5.36	5.78	5.61	--	5.45	--	2
	563	SV 391	4.87	3.62	4.34	4.39	4.36	--	--	--	--	1
	543	SV 392	6.67	4.73	5.94	5.74	5.84	--	--	--	--	1
	526	SV 393	6.42	3.92	5.72	4.75	5.24	--	--	--	--	1
	516	SV 394	4.08	3.74	3.63	4.54	4.09	--	--	--	--	1
	546	SV RR265	6.64	4.42	5.92	5.36	5.64	5.54	5.47	5.44	5.32	4
	567	SV RR268	5.60	4.00	4.99	4.85	4.92	5.02	5.02	5.12	5.01	4
	570	SV RR333	5.39	3.86	4.80	4.68	4.74	4.94	5.08	5.14	5.35	7
	541	SV RR351	6.13	3.90	5.46	4.73	5.10	5.20	5.12	5.30	4.96	5
	538	SV RR371	5.64	4.36	5.02	5.29	5.16	5.26	5.14	5.36	4.91	3
	519	SV RR375	5.75	3.97	5.12	4.82	4.97	5.24	5.31	5.51	5.44	3
1	1201	FS CK #07 CRYS658RR	4.00	3.67	3.56	4.45	4.01	3.77	3.46	3.53	2.85	14
1	1202	FS CK #08 HILL4000RR	6.95	4.73	6.19	5.74	5.96	5.89	6.12	5.81	6.59	12
1	1203	FS CK #09 HILL4010RR	7.96	5.11	7.09	6.20	6.64	6.28	6.32	5.91	6.41	14
1	1204	FS CK #12 HILL4012RR	6.70	4.36	5.97	5.29	5.63	5.65	5.73	5.68	5.89	14
1	1205	FS CK #13 HILL4043RR	6.69	4.77	5.96	5.79	5.87	5.80	5.97	5.73	6.31	13
1	1206	FS CK #18 CRYS768RR	4.71	3.87	4.20	4.69	4.45	4.65	4.56	4.85	4.37	11
1	1207	FS CK #28 SES36918RR	5.36	3.83	4.78	4.65	4.71	5.05	5.05	5.39	5.04	11
1	1208	FS CK #29 CRYS875RR	5.81	3.99	5.18	4.84	5.01	5.04	4.95	5.07	4.77	12
1	1209	FS CK #30 BTS8337	3.27	3.46	2.91	4.20	3.56	3.97	3.93	4.39	3.83	7
1	1210	FS CK #31 SXMarathon	6.13	4.50	5.46	5.46	5.46	5.17	5.06	4.88	4.84	5
	1211	FS CHK MOD RR RES #2	4.09	3.71	3.64	4.50	4.07	4.30	4.32	4.53	4.35	13
	1212	FS CHK MOD RR SUS #2	5.92	3.97	5.27	4.82	5.04	5.09	5.18	5.14	5.35	7
	1213	FS CHK RES RR #2	1.82	2.72	1.62	3.30	2.46	2.83	2.68	3.20	2.40	8
	1214	FS CHK SUS RR #10	5.97	4.10	5.32	4.97	5.15	5.16	5.17	5.17	5.20	6
	1215	FS CHK SUS RR #11	6.59	4.15	5.87	5.03	5.45	5.41	5.47	5.36	5.61	7
	1216	FS CHK SUS RR #2	7.41	4.27	6.60	5.18	5.89	5.84	6.02	5.80	6.37	9
		Conventional										
	902	Crystal 620	2.08	2.54	1.85	3.08	2.47	2.97	2.91	3.47	2.79	4
	907	Crystal 840	2.49	2.60	2.22	3.16	2.69	3.13	--	3.56	--	2
	904	Crystal 950	2.92	2.60	2.60	3.16	2.88	--	--	--	--	1
	906	Crystal R761	2.96	2.82	2.64	3.42	3.03	3.57	3.46	4.11	3.23	13
	903	Hilleshög HM3035Rz	4.70	3.29	4.19	3.99	4.09	4.27	4.08	4.45	3.70	15
	905	Seedex 8869 Cnv	3.65	3.16	3.25	3.83	3.54	3.65	3.61	3.77	3.53	4
	901	SV 48777	4.65	3.73	4.14	4.52	4.33	4.39	4.25	4.45	3.96	3
	1208	FS CK #29 CRYS875RR	5.52	4.17	4.92	5.06	4.99	5.03	4.94	5.07	4.77	12
	1209	FS CK #30 BTS8337	4.13	3.12	3.68	3.79	3.73	4.06	3.98	4.39	3.83	7
	1210	FS CK #31 SXMarathon	5.57	4.66	4.96	5.65	5.30	5.09	5.01	4.88	4.84	5
10		Check Mean	5.76	4.23	5.13	5.13	5.13					
		Trial Mean	4.16	3.45	3.71	4.18	3.95					
		Coeff. of Var. (%)	13.99	12.39	13.99	12.39						
		Mean LSD (0.05)	0.73	0.52	0.65	0.63						
		Mean LSD (0.01)	0.96	0.69	0.86	0.84						
		Sig Mrk	**	**	**	**						
		Adj Factor			0.89090	1.21300						
		@ Ratings adjusted to 2007 basis. (2005-2006 FS Nurseries). Ratings adjusted on the basis of checks.										
		+ Average rating based upon multiple rating dates. Lower numbers indicate better tolerance (1=Ex, 9=Poor).										

Table 29. Herbicides and Fungicides Applied to ACSC Official Trials

	Herbicide			Fungicide		
Location	Herbicide & Rate	Spray Dates	Method	Fungicide Used	Spray Dates	Method
Casselton*	RU1	6/14	Ground	AZteroid/Quadris	6/14,7/2	Ground
	RU2	7/2	Ground	CR.2/CR.3,CR.4	7/30,8/27,9/19	Ground
Glyndon	RU1	6/13	Ground	Quadris	6/6,6/29	Ground
	RU2	7/2	Ground	CR.1/CR.2/CR.3/CR.4	7/25,8/5,8/17,8/30	Ground
Climax	RU2	6/5	Ground	Quadris	6/12,6/28	Ground
	RU1	6/24	Ground	CR.1/CR.2/CR.3/CR.4	7/16,7/30,8/23,9/6	Ground
Grand Forks* +	Conventional	6/11,6/19	Ground	AZteroid/Quadris	5/10,7/2	Ground
				CR.1/CR.2/CR.3/CR.4	7/20,7/30,8/23,9/6	Ground
Scandia	RU2	6/5	Ground	Quadris	6/11,7/1	Ground
	RU1	6/24	Ground	CR.1/CR.2/CR.3/CR.4	7/16,7/30,8/23,9/6	Ground
	Conventional	6/6,6/17	Ground			
Argyle	RU2	6/5	Ground	Quadris	6/12,7/1	Ground
	RU1	6/24	Ground	CR.2/CR.3,CR.4	8/2,8/14,8/30	Ground
Kennedy	RU1	6/20	Ground	Quadris	6/14,7/8	Ground
	RU2	7/8	Ground	CR.2/CR.3,CR.4	8/2,8/14,8/30	Ground
Bathgate#	RU1	6/12	Ground	Quadris	6/5,6/24	Ground
	RU2	7/1	Ground	CR.2/CR.3,CR.4	8/2,8/14,8/30	Ground
	Conventional	6/12,6/19	Ground			

Ground applications made by beet seed personnel from Crystal Technical Services Center.

RU1 = Roundup Powermax (32 oz./A), Event (1 gal./100 gal water).

RU2 = Roundup Powermax (22 oz./A), Event (1 gal./100 gal water).

+ Counter 20G applied at 9.0 lbs./A at Grand Forks.

Lorsban applied for SBRM near peak fly.

Quadris=first application on 2 leaf beets, second on 4-8 leaf beets.

*AZteroid infurrow was used instead of first Quadris application.

CR.1=Insire XT + Manzate

CR.2=Agritin + Incognito

CR.3=Proline+Manzate

CR.4=Priaxor + Agritin

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